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DEPLOY/RETRIEVE STORAGE SYSTEM (DRSS). VOLUME I. SYSTEM LEVEL D--ETC(U)
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1 OF 2
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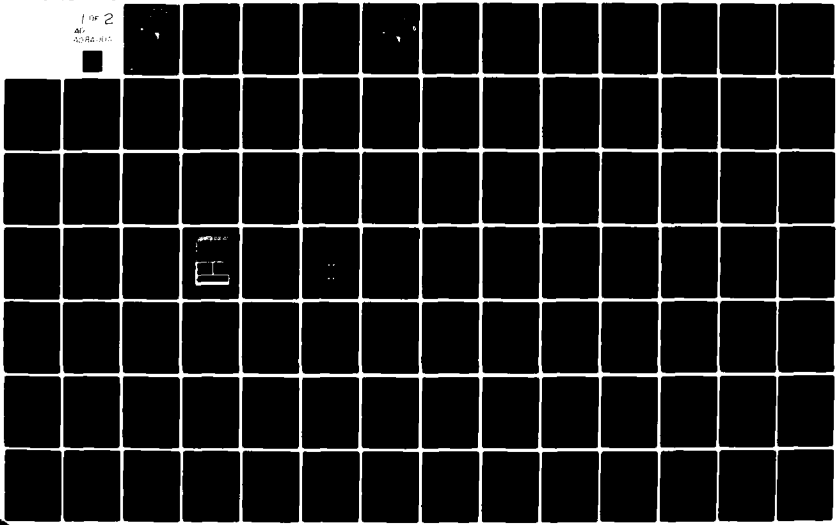

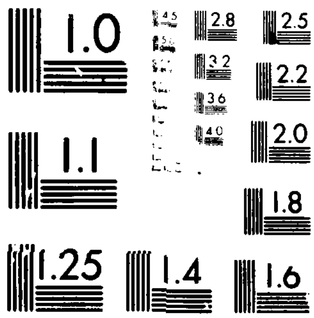

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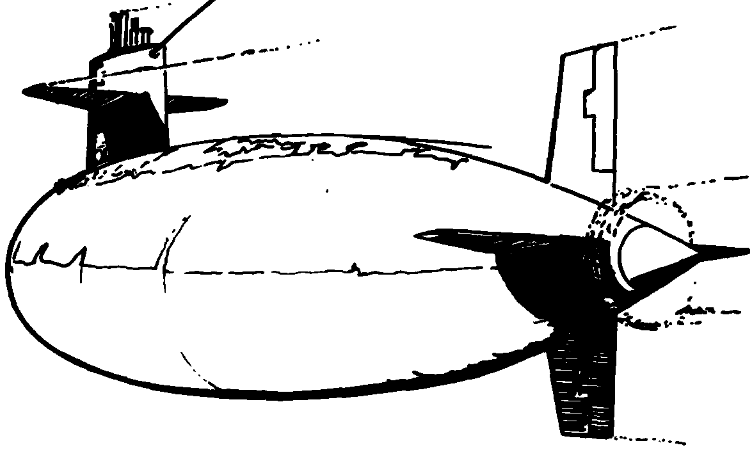
DEPLOY/RETRIEVE STORAGE SYSTEM (DRSS)

LEVEL II

VOLUME I
SYSTEM LEVEL DEFINITION AND TRADEOFF ANALYSIS

ADA084004



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SUBMITTED TO:

DEPARTMENT OF THE NAVY,
NAVAL ELECTRONIC SYSTEMS COMMAND
WASHINGTON, D.C. 20360

IN RESPONSE TO:

CONTRACT NO. N00039-79-C-0329

SUBMITTED BY:

GOULD

CHESAPEAKE INSTRUMENT DIVISION
6711 BAYMEADOW DRIVE
GLEN BURNIE, MARYLAND 21061

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GOULD

DEPLOY/RETRIEVE STORAGE SYSTEM (DRSS)

CONCEPT STUDY FINAL REPORT,

VOLUME I

SUBMITTED TO:

Department of the Navy
Naval Electronic Systems Command, ELEX 3102
Washington, D.C. 20360

C

IN RESPONSE TO:

Contract No. N00039-79-C-0329
June 1979 through January 1980

SUBMITTED BY:

Gould Inc.
Chesapeake Instrument Division
6711 Baymeadow Drive
Glen Burnie, MD 21061

Report Number 1 January 31, 1980

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Contract N00039-79-C-0329

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VOLUME I
SYSTEM LEVEL DEFINITION AND TRADEOFF ANALYSIS

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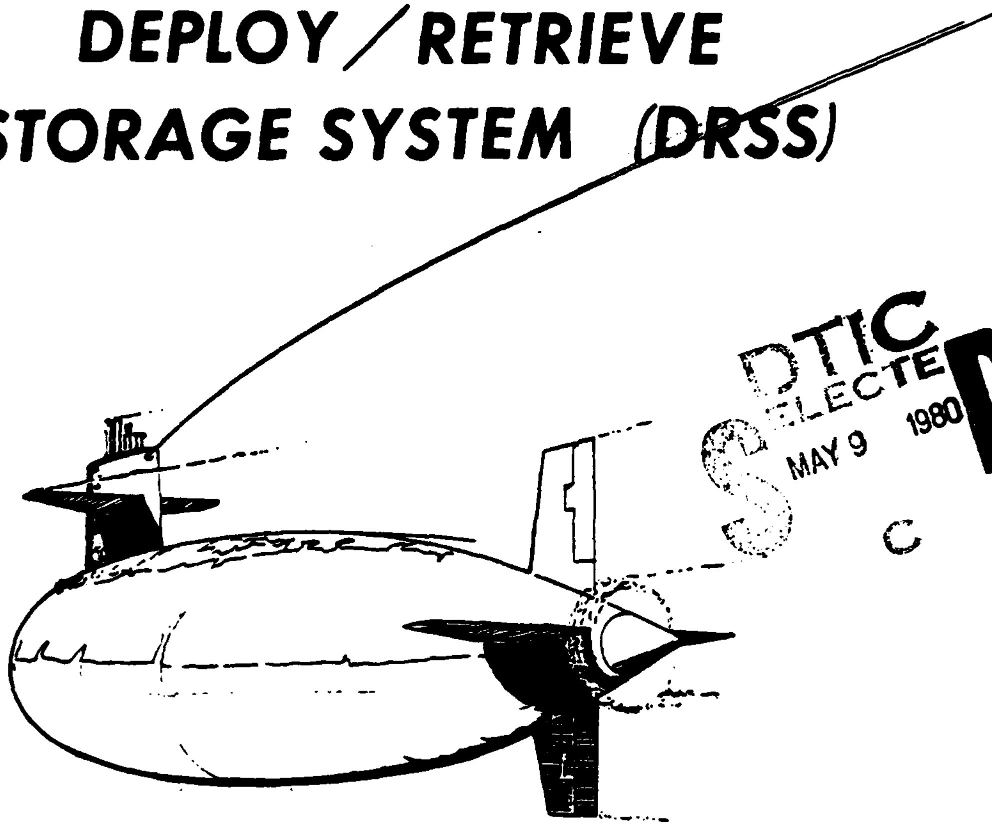
DEPLOY / RETRIEVE STORAGE SYSTEM (DRSS)



-ERRATA SHEETS-

DRSS PHASE 1A FINAL REPORT

GOULD

Gould Inc., Chesapeake Instrument Division/Glen Burnie, Maryland 21061

SUMMARY: MISCELLANEOUS CORRECTIONS TO DRSS PHASE IA FINAL REPORT VOLUME I - SECTION 1

p 2. Why can Concept B not handle 1.0 inches?

Explanation: B can handle 1.0 inches. Refer to page 3.3.2.1.

p 8. Concept D . . . . . For Proper Handling?

Explanation: Cannot establish method for handling of the BCA without excessive bending/reverse bending, due to the long cylindrical form factor configuration of the MAT.

p 8. Concept B . . . . . Weight exceeded by 22%?

Explanation: Based upon a detailed weight analysis this is accurate to the level of breakdown established for the Phase 1A effort.

Concept B . . . . . Seals act on 0.65 to 1.0?

Explanation: Wrong interpretation of the nature of a fixed 2-position Dynamic Seal, which is the recommended candidate concept. Only a single diameter seal is possible for this concept.

p 9. Table I . . . . Too detailed?

Explanation: The tabulation is an approximation of the actual sequence to be defined at a later date. Its intent is to allow the reader to develop a reasonable feel for how a staging tube would be employed. All times are meant to be representative at this stage of conceptional characterization.

p 10. Table 2 . . . . Too detailed?

Explanation: Refer to Section 3 for a detailed description. A detailed pictorial representation of Concept B will be provided as part of the Phase 1B-1 study effort and will be provided at the earliest possible date.

VOLUME 1 - SECTION 2

p 13. Objective 3 . . . . Meeting subsafe requirements?

Explanation: As specified in the SOW

VOLUME 1 - SECTION 3

p 25. Para 3.2.3 . . . . . Minimum seawater leakage part the first seal into the annulus. NUSC comments "NO!"

Explanation: This must be resolved during testing. Zero leakage is an unrealistic requirement for a dynamic seal. The water film on the BCA jackets (at .0003 inches thick) equals 36 inches^3

of water brought inboard vs an allowance dynamic seal leakage of 12 $inches^3$/minute reflects a best estimate of performance under actual operating conditions.

p 25.	Para 3.2.3	Failsafe?
	Explanation:	Failsafe is defined as a component or subsystem reverting to the desired "most-safe" functional status in the event of control or power failure.
p 28. p 29.	Table 3.2.3.1 . . . Table 3.2.3.2	Why is included at this point?
	Explanation:	For maximum clarity in presentation of the staging tube operation, referring to Figure 3.2.3.1.
p 31.	Figure 3.2.3.4 . . .	Not a SUBSAFE type design!
	Explanation:	Conceptional feasibility only.
p 38.	Para 3.3.1.1	Failsafe?
	Explanation: &D	See previous description Change (19) to (9)
p 49.	Para 3.3.2.4.1 . .	NUSC suggestion that loading a lump into the staging tube w/o buckling is a major risk area.
	Explanation:	Agreed.
p 52.	Figure 3.3.2.3.1 .	Repeated for 3rd time?
	Explanation:	Required for full descriptive explanation of Concept B
p 55.	Para. 3.3.3.3	Change DRSS to antenna
p 58.	Figure 3.3.3.2.2 .	Concept C -- Operational/Performance at only 4" Ø?
	Explanation:	4"Ø was the minimum requirement. Further detailed definition is essential in order to ascertain capability of the system concept configurations to achieve 6"Ø.
p 60.	Para 3.3.4.1	Change .50 → 1.00 to .65 → 1.38 inch
p 63.	Figure 3.3.4.2.2 .	MTBF?
	Explanation:	Intrinsic/relative value employed for comparison of the different system concepts. The derivation is correct for Mean Time Between Failure. Additionally, if an average deploy/retrieve cycle takes 20 minutes, the MCBF would be MTBF/.6667 Per cycle or 324 full deploy/retrieve cycles prior to a DRSS failure.

p 68.	Figure 3.3.5.2.2 .	Concept E -- Opn'l/Performance at only 4"Ø?
	Explanation: & Explanation:	Refer to p 58 explanation . . . . . MTBF? See above.
p 69.	Maintenance Operation . . . Change "Ø to 4"Ø	

VOLUME I - SECTION 4

p 74.	Para. 4.2(a)	Change Mean Value from 58.27 to 58.51 Change Standard Deviation from .856 to .943 Change Sys. Concept B from 58.57 to 59.07
p 76.	Figure 4.2.2	Change Subtotals as follows: 52.17 ----- no change 52.57 ----- to 52.73 52.58 ----- to 52.43 47.76 ----- to 45.13 51.96 ----- to 52.05
p 76.	Figure 4.2.2	Change Grand Totals as follows: 59.24 ----- no change 58.57 ----- to 59.07 57.46 ----- to 57.16 52.39 ----- to 49.76 58.55 ----- no change
p 77.	Para 4.2(b)	Change System Concept D from 52.73 to 49.76

VOLUME I - APPENDIX A

p A-3 Requirement 7 -- Change the following:

Concept A -- para 1.6 to Figure 3.3.1.2.2
Concept B -- para 1.6 to Figure 3.3.2.2.2
Concept C -- para 1.6 to Figure 3.3.3.2.2
Concept D -- para 1.6 to Figure 3.3.4.2.2
Concept E -- para 1.6 to Figure 3.3.5.2.2

p A-4 Requirement 11 - Change the following:

Concept A -- para 1.6 to Figure 3.3.1.2.2
Concept B -- para 1.6 to Figure 3.3.2.2.2
Concept C -- para 1.6 to Figure 3.3.3.2.2
Concept D -- para 1.6 to Figure 3.3.4.2.2
Concept E -- para 1.6 to Figure 3.3.5.2.2

and under Concept D, change 2" max to 1.38" max

p A-5 Requirement 19 - Change the following:

Concept A -- para 1.6 to Figure 3.3.1.2.2
Concept B -- para 1.6 to Figure 3.3.2.2.2
Concept C -- para 1.6 to Figure 3.3.3.2.2
Concept D -- para 1.6 to Figure 3.3.4.2.2
Concept E -- para 1.6 to Figure 3.3.5.2.2

p A-7 Goal 4 - Change 6X greater than to 13.34X & 12.54 inches/5000 ft to 25.08 inches/5000 ft. (This would be a worst case variance if an antenna system 5000 ft long of 0.65 diameter cable was either continuously undersize or oversize. If the cable diameter however, varied over the range specified, the estimated error in scope would be significantly less than the "worst case" 25.08 inches/5000 ft.

p A-9 Development Risk -- Delete

Explanation: This analysis should have been deleted. Insufficient data to adequately define at this time.

Repairability -- Deleted

Explanation: This analysis should be deleted. Insufficient data to adequately define at this time.

p A-10 Interface Requirements Factor -- Change the following:

Concept A -- para 1.6 to Figure 3.3.1.2.2
Concept B -- para 1.6 to Figure 3.3.2.2.2
Concept C -- para 1.6 to Figure 3.3.3.2.2
Concept D -- para 1.6 to Figure 3.3.4.2.2
Concept E -- para 1.6 to Figure 3.3.5.2.2

p A-5 Requirement 19 - Change the following:

Concept A -- para 1.6 to Figure 3.3.1.2.2
Concept B -- para 1.6 to Figure 3.3.2.2.2
Concept C -- para 1.6 to Figure 3.3.3.2.2
Concept D -- para 1.6 to Figure 3.3.4.2.2
Concept E -- para 1.6 to Figure 3.3.5.2.2

p A-7 Goal 4 - Chnage 6X greater than to 13.34X & 12.54 inches/5000 ft. to 25.08 inches/5000 ft. (This would be a worst case variance if an antenna system 5000 ft. long of 0.65 diameter cable was either continuously undersize or oversize. If the cable diameter however, varied over the range specified, the estimated error in scope would be significantly less than the "worst case" 25.08 inches/5000 ft.

p A-9 Development Risk -- Delete

Explanation: This analysis should have been deleted. Insufficient data to adequately define at this time.

Repairability -- Deleted

Explanation: This analysis should be deleted. Insufficient data to adequately define at this time.

p A-10 Interface Requirements Factor -- Change the following:

Concept A -- para 1.6 to Figure 3.3.1.2.2
Concept B -- para 1.6 to Figure 3.3.2.2.2
Concept C -- para 1.6 to Figure 3.3.3.2.2
Concept D -- para 1.6 to Figure 3.3.4.2.2
Concept E -- para 1.6 to Figure 3.3.5.2.2

SECTION 1

SECTION 1

SUMMARY

This purpose of this study was to develop system concept(s) for a Deploy/Retrieve/Storage System (DRSS) for present and future Radio Frequency Buoyant Cable Antenna Systems on SSN and SSBN submarines, and provide the basis for investigation of performance, installation and cost tradeoffs. The DRSS shall functionally replace the antenna transfer mechanism, antenna storage reel, pressure hull interface, conduit and tow/exit point presently installed on submarines as part of the existing AN/BRA-18 and AN/BRA-24, systems.

The present system has the following major problem areas: exerts excessive compressive, bending, torsional and tensile forces on in-line electronic, connectors and antenna assemblies developed for present and future antennas; restricts the development of future antennas and associated components; requires extensive effort for maintainability; requires a bend radius of 6" on in-line electronics and associated components; introduces excessive structureborne noise; requires excessive manpower/effort to deploy/retrieve/store antenna assemblies; and does not accurately determine amount of cable deployed.

The basic guidelines for the study were to establish an analysis of conceptual means to deploy, retrieve and store buoyant cable antenna systems. Twenty specific requirements were placed upon the conceptual system. Additionally, five goals were to be achieved.

Since the analysis was to be conducted in a tradeoff study format, the tradeoff priorities which were established in the contract SOW were:

1. Performance based on achieving the maximum number of design goals specified in Paragraph 3.2.3 of the contract SOW.
2. Installation impact on available space and weight within the existing superstructure.

3. Per unit cost based on achieving the maximum number of design goals specified in paragraph 3.2.3 of the contract SOW.

Additionally, the following production cost and installation cost goals were provided in the contract SOW:

Production Cost $175K

Installation Cost $200K

The DRSS Concept Study was divided into two parts which comprise the two volumes of this report. Volume I details the system level definition and tradeoff analysis. Volume II details the component level definition and tradeoff analysis.

Five separate System Concept Configurations have been generated for this tradeoff study and are as follows:

Concept A - For Handling Moderate Diameter Antenna Elements (Figure 1)

Concept B - For Handling Large Diameter Antenna Elements (Figure 2)

Concept C - Enclosed in Pressure Proof Access Trunk (Figure 3)

Concept D - Located in Main Access Trunk (Figure 4)

Concept E - Located in Aft Main Ballast Tank (Figure 5)

Concept A

Concept A utilizes a continuously variable dynamic seal which opens to pass the larger diameter antenna element. Although this concept is simple, it was found that the maximum diameter it could handle is 1.0 inches.

Concept C

Concept C utilizes a pressure proof access trunk to house all its equipment. Since this trunk is free flooded, all cable antenna seals are eliminated. Thus the operation is analogous to a handling system located external to the pressure hull. Although this concept is simple and inherently reliable, it was discarded because of the unit cost, installation cost and general lack of practicality in a backfit program.

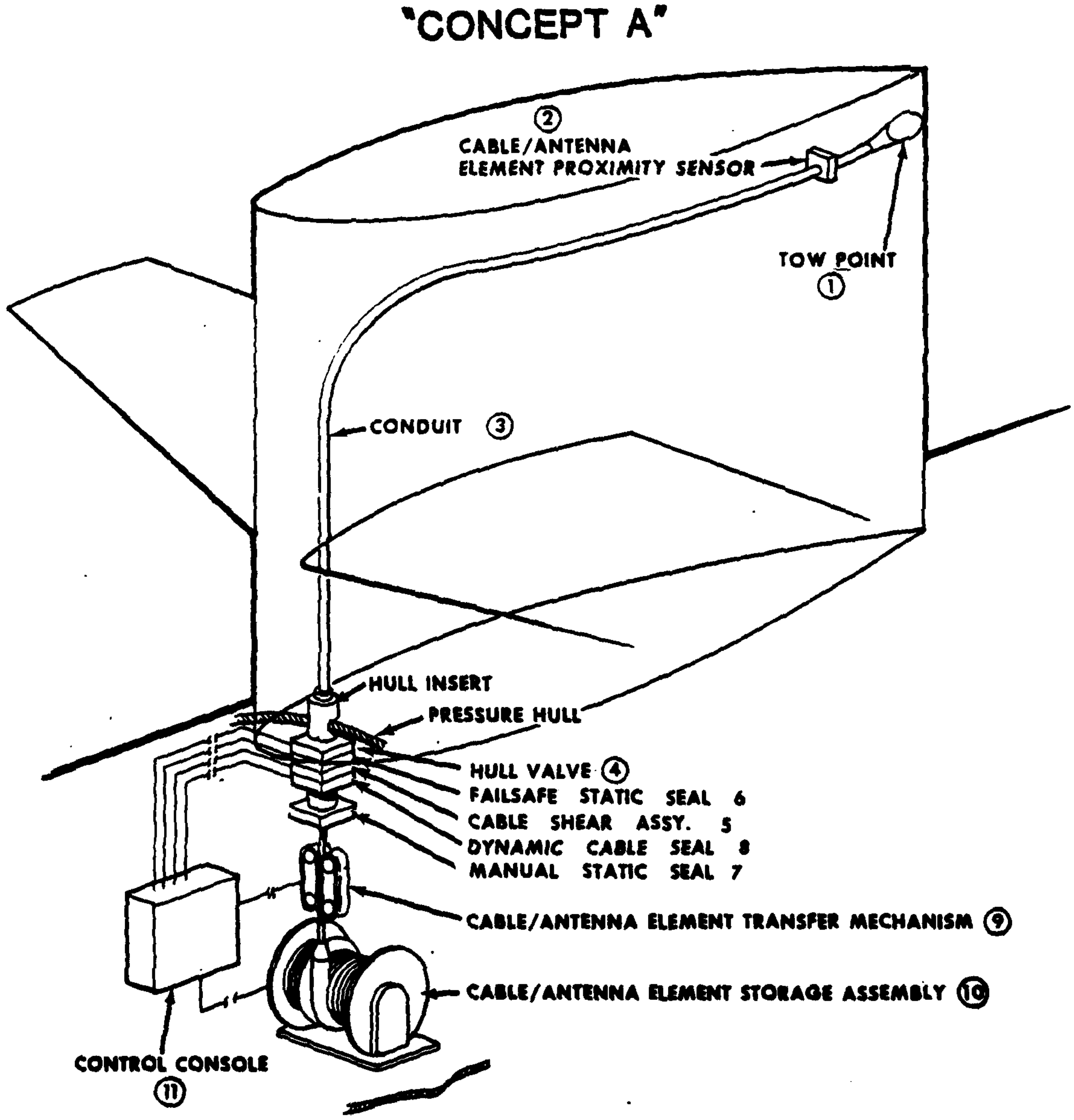


Figure 1. System Concept A

"CONCEPT B"

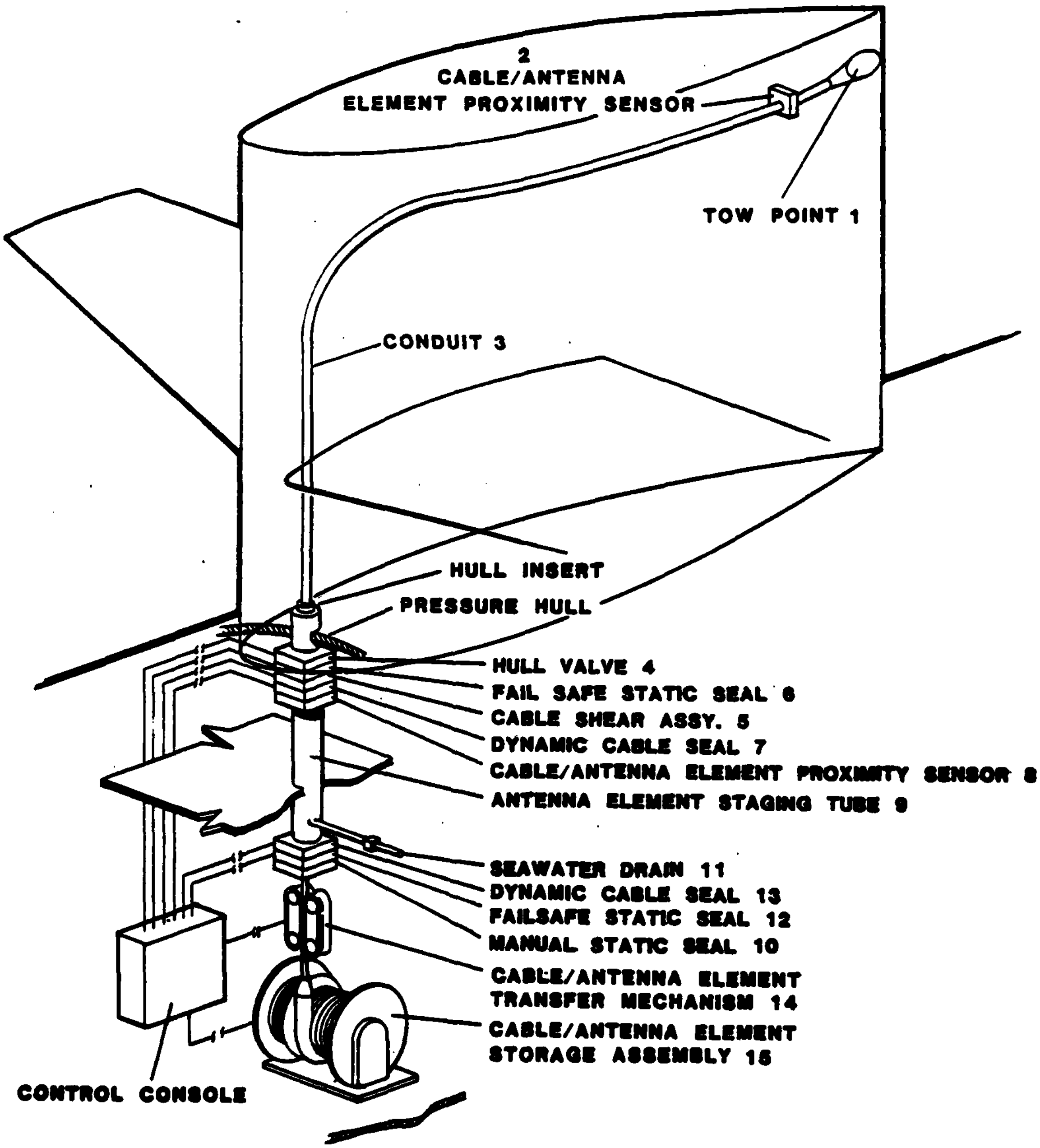


Figure 2. System Concept B

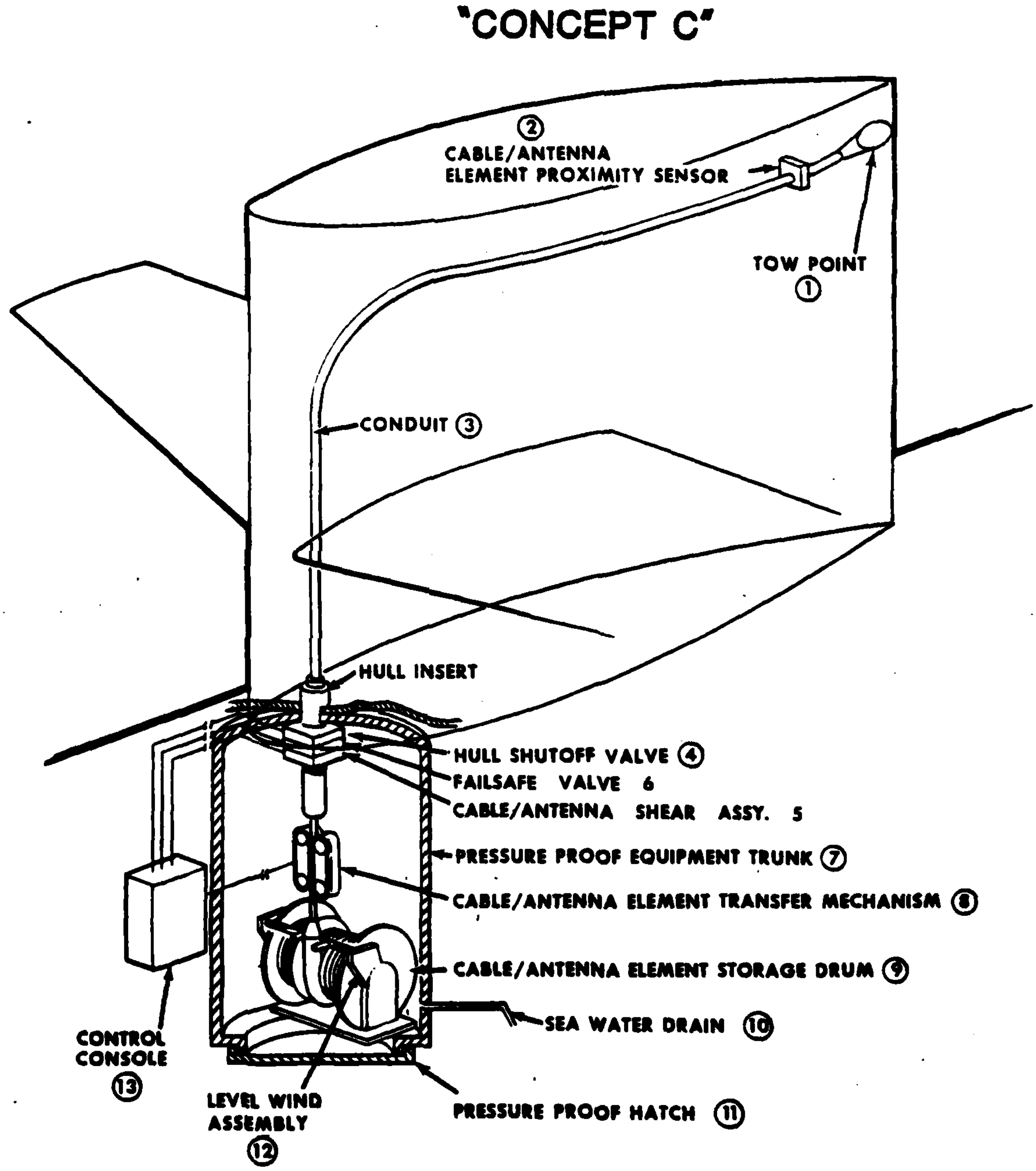


Figure 3. System Concept C

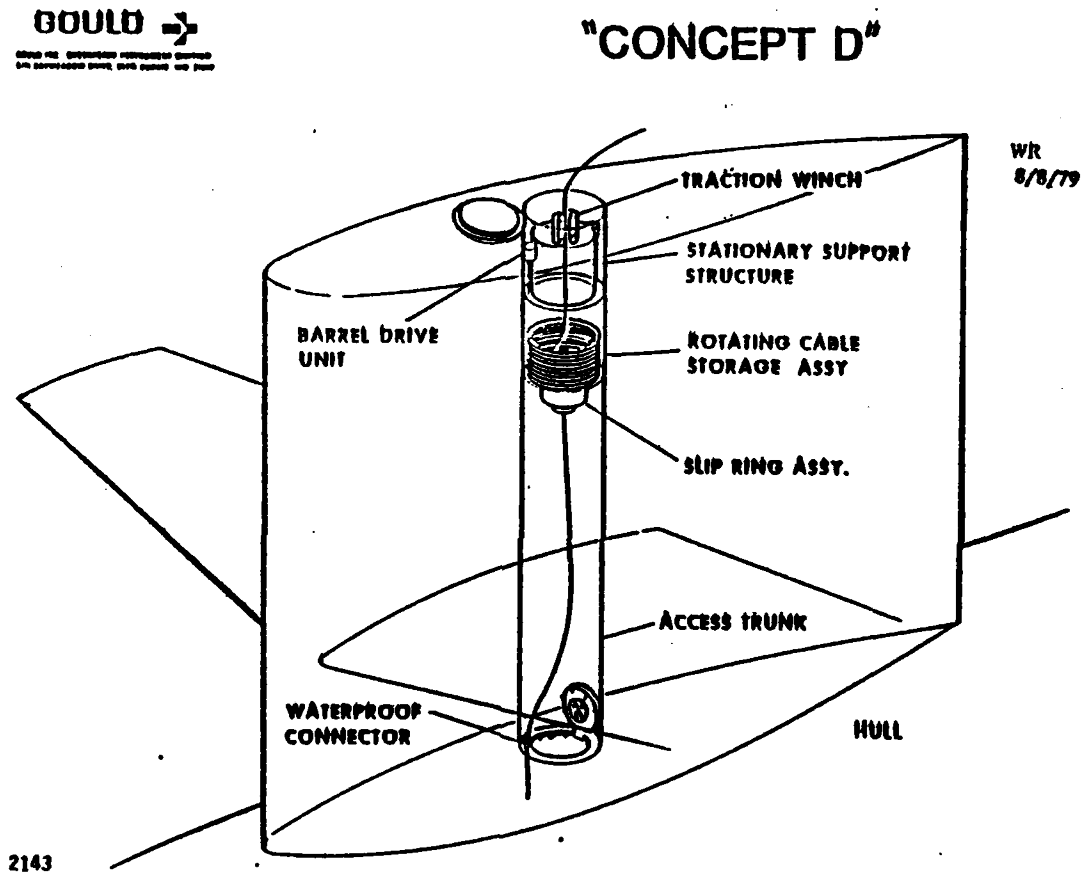


Figure 4. System Concept D

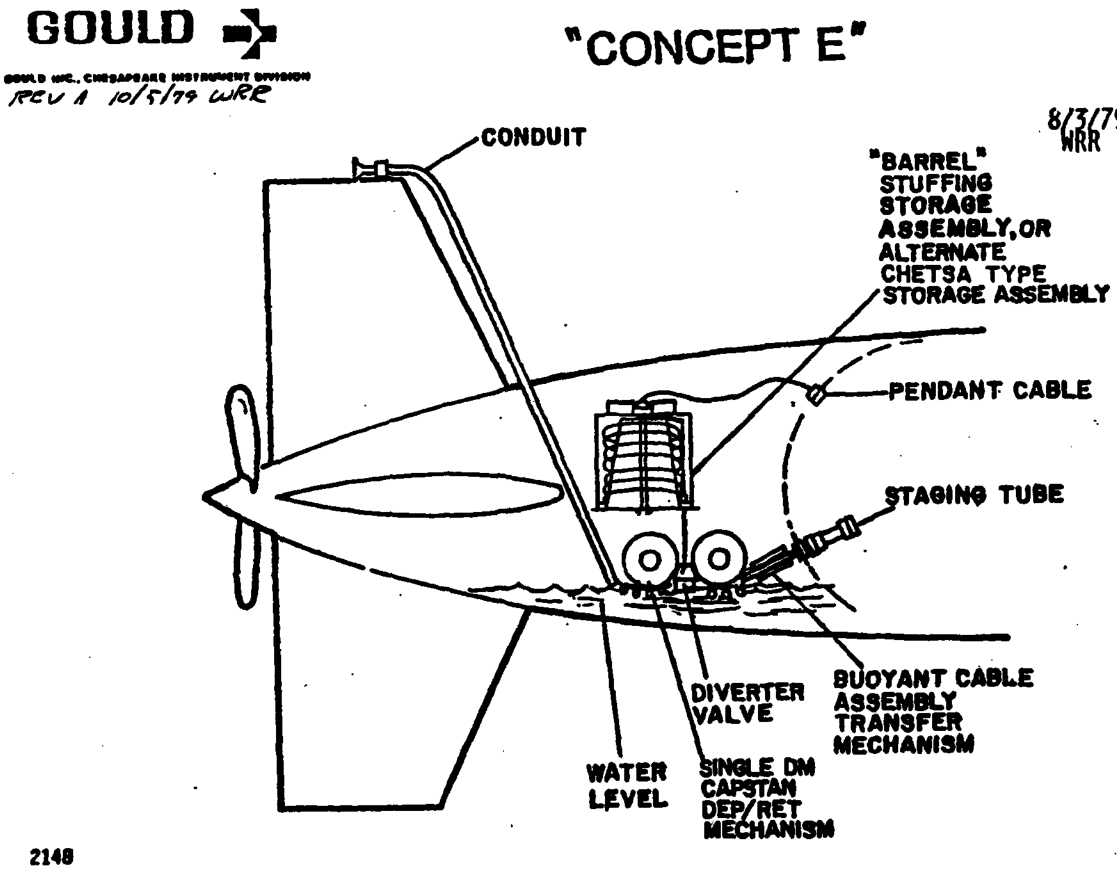


Figure 5. System Concept E

<u>Concept D</u>

Concept D located all components in the main access trunk which can then free flood to achieve a system which eliminates cable/antenna seals. This concept was discarded because the form factor of the trunk did not allow for proper handling of the cable/antenna element assembly. It was also unsatisfactory from the standpoint of blocking and flooding the main access trunk.

<u>Concept E</u>

Concept E located all components outside the pressure hull, but allowed cable/antenna maintenance by pushing it through the pressure hull <u>only</u> when maintenance was required. This concept was discarded because of lack of maintenance availability of the handling system itself and because of the complex nature of the mechanism which diverted the cable/antenna element assembly into the pressure hull.

<u>Concept B</u>

Concept B was selected as the most viable concept for the DRSS system. Analysis of this concept showed that it meets all contractual requirements and goals except for total system weight which it exceeded by only 22%.

This concept utilizes an antenna element staging tube to provide means to equalize the pressure differential imposed on the antenna element, when passing through the pressure hull boundary. As a 4 inch diameter x 4 foot long antenna element is passed through the staging tube during deployment or retrieval, the dynamic seal assemblies at each end of the staging tube are sealed against the 0.65 inch diameter cable and the staging tube flooded. As each 4.0 inch diameter antenna element is encountered during deployment or retrieval, the staging tube is alternately pumped dry or flooded. A series of antenna element proximity sensors are used to control the placement of the antenna element in the staging tube. The seals act only on the cable and, thus, are limited to a single diameter. Detailed operation of Concept B is described in Tables 1 and 2.

The major development risk areas from the chosen concept are the transfer mechanism which must be capable of applying large retrieval forces to the cable/antenna

Table 1

Antenna Element Passage through Staging Tube Configuration

Time, Sec.	DEPLOYMENT	Time, Sec.	RETRIEVAL
	Sense Antenna Element @'A' w/AEPS #2		Interlock Cable Scope Count @T.B.D. Feet, reduce to 1/10th Speed
12.0 ± 3.0	Stop	12.0 ± 3.0	Sense Antenna Element @'B' w/AEPS #1
(49.0)[1]	Vent Staging Tube (DCSA #1 activated)		Stop
(3.0)[1]	Open DCSA #2		
28.5 ± 3.0	Start and Continue Deployment Increment Scope by T.B.D. Feet @ 1/10th Speed	28.5 ± 3.0	Start and Continue Retrieval. Decriment Scope by T.B.D. Feet @ 1/10th Speed
1.5	Stop	1.5	Stop
3.0	Close DCSA #2	3.0	Close DCSA #1
49.0	Fill Staging Tube, Equalize Antenna Element @ Ambient Seapressure	49.0	Vent Staging Tube, Equalize to Ambient Atmosphere
3.0	Open DCSA #1	3.0	Open DCSA #2
12.0 ± 3.0	Start and Continue Deployment @200 → 400 FPM	12.0 ± 3.0	Start and Continue Retrieval @200 → 400 FPM
109.0±9.0		109.0±9.0	

NOTES:

(1) (49.0) and (3.0) are not included if DCSA #1 employed prior to Antenna Element sense at 'A'. A 2nd Antenna Element would require these two steps.

(2) The Staging Tube Vent/Fill time of 49.0 seconds is based upon the following: 7.5 ft. long annulus, 5.0 in. I.D. w/4 in. O.D. Antenna Element 4.0 ft. long; Estimated Displacement Volume required equals < 4.5 Gallons; the Vent/Fill line bore of 3.0 in., with seawater velocity ≤ 3.0 FPS provides rate of .092 GPS; 4.5 Gallons/.092 GPS = 49.0 seconds.

Table 2
Cable End Termination Passage through Staging Tube Configuration

DEPLOYMENT

Time, Sec.	
4.5	Power up, Disengage Pawl & Start Deployment @1/10th Speed
	Sense Cable End Termination @'A' w/AEPS #2
1.5	Stop
3.0	Open FSV #2
	Start @1/10th Speed
28.5 ± 3.0	Passage of Cable End Termination through DSA #2 Staging Tube & DSA #1
	Sense Cable End Termination @'B' w/AEPS #1, Activate DSCA #1
1.5	Stop
(49.0)[1]	Fill Staging Tube, Equalize @Ambient Seapressure
3.0	Open FSV #1 & HV
12.0 ± 3.0	Start & Deploy @200 → 400 FPM until Desired Scope
54.0 ± 6.0	

RETRIEVAL

Time, Sec.	
	Power up, Disengage Pawl, MSSV & Start Retrieval @200 → 400 FPM
	Interlock Cable Scope Count @T.B.D. Feet, reduce to 1/10th Speed
12.0 ± 3	
	Sense Cable End Termination @'B' w/AEPS #1
1.5	Stop
3.0	Close HV & FSV #1
(49.0)[1]	Vent Staging Tube, Equalize to Ambient Atmosphere
	Start @ 1/10th Speed
28.5 ± 3.0	Passage of Cable End Termination through DCSA #1 Staging Tube and DCSA #2
1.5	Sense Cable End Termination @4' w/AEPS #2. Stop.
3.0	Close FSV #2, Deactivate DCSA #1
	Continue Retrieval @1/10th Speed until Scope equals 0
4.5	Stop, Engage Pawl & Power Down
54.0 ± 6.0	

NOTES:

(1) The (49.0)* seconds is not included in the total passage time if DSCA #1 is employed as the operational dynamic seal.

(2) Optimization of the sequence and representative times must be made through further Detailed Definition. The above operational modes are <u>representative only</u>!

system while also articulating to accommodate the abrupt diameter changes, and the dynamic cable seals which must apply minimal shear forces to the cable and must also open to a 4.0 inch diameter bore to pass the antenna element. It is recommended that further study and modeling be done on these components.

SECTION 2

SECTION 2

CONTRACT REQUIREMENTS

2.1 INTRODUCTION

The following paragraphs establish the foundation for the study and tradeoff analysis for a conceptual design of a Deploy/Retrieve/Storage System (DRSS) for present and future Radio Frequency Buoyant Cable Antenna Systems on SSN and SSBN submarines, and provide the basis for investigation of performance, installation and cost tradeoffs. The DRSS shall functionally replace the antenna transfer mechanism, antenna storage reel, pressure hull interface, conduit and tow/exit point presently installed on submarines as part of the existing AN/BRA-18 and AN/BRA-24, systems.

The concept(s) and tradeoff analysis developed within this study effort shall address the technical objectives, requirements and goals within the SOW. The DRSS concept study shall address as a system and individually the following:

- Deploy/Retrieve Mechanism
- Cable Storage
- Cable Guide
- Tow/Exit Point

Although the Antenna Assembly is not considered part of the DRSS, it is important that the electrical/mechanical performance characteristics of the Antenna Assembly be considered; and also the impact of the design of the DRSS on the electrical/mechanical parameters of the Antenna Assembly, and the electrical/mechanical interface parameters at the inboard end of the DRSS. The Near Term Buoyant Cable System, including antenna assembly interface, is specified on NUSC drawings 02702-001 and 02702-002, and is used as guidance.

2.2 TECHNICAL OBJECTIVES

The specific technical objectives were defined as follows in the SOW:

1. <u>Deploy/Retrieve Mechanism</u>

   The concept(s) shall develop a system/method for deploying and retrieving present and future antenna assemblies at maximum tow speed and cable lengths. The concept shall utilize power available onboard the submarine. The deploy/retrieval mechanism shall be compatible with all in-line components, cables and antenna assemblies.

2. <u>Cable Storage</u>

   The concept(s) shall address a method for storage of any portion of the antenna assembly not deployed. The storage portion of the DRSS shall also be the inboard termination/connectivity of the antenna assembly to rf subsystems.

3. <u>Cable Guide</u>

   The concept shall address inter-connecting of individual subsystems including tow/exit point within the DRSS as required to meet the overall intent of the SOW. The method, size, shape and material shall be compatible with the system and not impose constraints or excessive loading on present or future antenna assemblies and associated in-line component. Pressure hull boundaries/interfaces shall be capable of meeting subsafe requirements.

4. <u>Tow/Exit Point</u>

   The concept shall optimize the tow/exit point location shape and size to obtain maximum speed/depth performance from the antenna system and sustain the loading imposed by high speed/long cable length towing. The tow/exit point shall not impose constraints or excessive loading on cable, in-line components or antennas of present and future antenna assemblies.

2.3 REQUIREMENTS

In developing a DRSS System Concept, and addressing the technical objectives, the following requirements, per Paragraph 3.2.2 of the SOW, must be achieved:

1. The system shall be positive self-sealing under all conditions at all external interfaces to maximum depth of the submarine.
2. The system shall be capable of shearing the antenna assembly and completely sealing the pressure hull boundary.
3. The structureborne and airborne noise (within one (1) foot of any portion of the DRSS), at all payout/retrieval speeds shall not exceed the levels specified in NUSC drawings SKA-55250 and SKA-55251 respectively.
4. The antenna assembly including all antenna elements and in-line devices shall be deployed and totally retrieved while the submarine is submerged at all depths.
5. The system shall not exert excessive compressive, torsional bending or tensile loading within the DRSS.
6. Typically, the system shall be installed within the confines of the existing superstructure of SSN 637 and 688 submarine and compatible with SSBN submarines.
7. The total volume of the DRSS shall not exceed 85 cubic feet.
8. The deploy, retrieve mechanism and storage portion of the DRSS shall be accessible for repair/maintenance while the submarine is submerged.
9. The in-line connectors, electronic and housing connectors shall be similar to that shown on NUSC drawings D-02387-001, D-02386-001 and D-02378-001 but may vary in diameter according to the cable utilized. The maximum length shall not exceed 6 ft. in length and 1.0 inch in diameter. Minimum requirement length is 12 inches and 0.650 $\pm$0.025 inches in diameter.
10. The cable structure and materials shall be similar to buoyant cables specified in NUSC Specification NUSC-C-342/4141-279.

11. The antenna elements associated with the antenna assembly shall not exceed 6 ft. in length and 6 inches in diameter. Minimum requirement is 4 ft. long and 4 inches in diameter.
12. The antenna assembly length shall not exceed 5000 ft. based on a nominal cable diameter of 0.650 inches. Minimum requirement is 3000 ft. with cable diameter of 0.650 inches.
13. The maximum static tensile loading at the tow point shall not exceed 10,000 lbs. Minimum requirement is 6000 lbs.
14. The cable diameter shall be 0.650 to ±0.020 inches in diameter.
15. The maximum payout/retrieval speed of the DRSS shall not be less than 200 fpm.
16. The DRSS shall be capable of sustaining a minimum dynamic loading of 3000 lbs. within the cable.
17. The cable deployed shall be measured and indicated to within ±5 feet.
18. The DRSS system shall not require more than 2 persons with technical ratings to operate/control the deploy/retrieve and storage.
19. The total weight of the DRSS including foundations, controls, etc., shall not exceed 3500 lbs.
20. The maximum power available within the pressure hull or superstructure for DRSS utilization is assumed to be the following:

    Hydraulic - 3000 psi with max. flow rate of 30 gpm

    Electrical - 220/440 VAC-60 Hz with 300/250 amps

2.4 GOALS

Additionally, the concept(s) shall be based upon and tradeoff analyses made upon the following goals taken from paragraph 3.2.3 of the SOW:

1. A design goal of the DRSS is to be compatible with cable which can vary in diameter between 0.50 and 1.00 inches. The diameter would remain constant with ±0.025 inches for relatively long lengths of cable. The

specific gravity of the cable could be between 0.60 and 0.75 of 0/psi hydrostatic pressure for all cable diameters specified.

2. A design goal is to provide the DRSS with a capability to payout and retrieve cable at speeds not less than 400 fpm.
3. As a design goal, the maximum dynamic tensile loading the DRSS shall sustain is 6000 lbs. at maximum cable retrieval speeds.
4. A design goal of the DRSS is to measure the amount of cable paid out to within ± 1 foot.
5. A design goal of the DRSS system is operation/control of deploy/retrieve/ storage by one person with a technician rating.

Goals are specifically important design drivers at the systems level.

2.5 TRADEOFF PRIORITIES

In developing the DRSS concept(s) the order of priorities for tradeoff studies shall be as follows:

1. Performance based on achieving the maximum number of design goals specified in Paragraph 3.2.3 of the SOW.
2. Installation impact on available space and weight within the existing superstructure.
3. Per unit cost based on achieving the maximum number of design goals specified in Paragraph 3.2.3 of the SOW.

2.6 DESIGN TO COST

The goal of a moderate cost DRSS is an essential part of this program. The cost shall be considered when performing tradeoff analysis of the concept(s) including the individual subsystem. Cost goals are based on FY 79 dollars, assuming quantities (by year) shown in Table I. The quanitities shown are established for tradeoff analysis only, and do not indicate actual plans or intent for procurement of production units. The design to cost goals shall not exceed:

DRSS Production Cost - $175K

Installation Cost - $200K

Table I

	1985	1986	1987	1988
DRSS (SSN and SSBN)	10	30	30	50-70

SECTION 3

SECTION 3

SYSTEM DEFINITION

3.1 INTRODUCTION

The scope in this study effort has been limited to conceptual characterizations and tradeoff studies responsive to SOW requirements and of sufficient detail to base CID recommendations to the Government for decision on possible future DRSS development work. Severe requirements are imposed on the DRSS system by operational, installation and SUBSAFE constraints. Additionally, the interaction of the DRSS with the Buoyant Cable Antenna (BCA) system must be addressed and integrated into the analyses.

A typical present day buoyant cable system consists of the following:

1. Deploy/Retrieve Mechanism is a mechanical device located inboard of the pressure hull for paying out and retrieving the antenna assembly while the submarine is submerged. The present buoyant cable systems include either the AN/BRA-24 ( ) or the AN/BRA-18 antenna transfer assemblies. The AN/BRA-24A is identified in NAVSEA Technical Manual 096-LP-301-2010, AN/BRA-24C in NAVSEA Technical Manual 0967-LP-608-5010 and the AN/BRA-18C in NAVSHIPS Technical Manual 0967-LP-325-8010.

2. Cable Storage is a mechanical device located inboard, and is used to store the complete antenna assembly when retrieved, and is the mechanical electrical inboard termination/mating point for the antenna assembly. The reel assembly normally has a storage capacity of approximately 2200 feet of buoyant cable. The Buoyant Cable Antenna Assembly used with the existing deploy/retrieve system consists of approximately 2000 ft. of buoyant cable manufactured in accordance with MIL-C-28726(EC) and MIL-C-28751(EC). The antenna can include flexible in-line connectors, electronics and antennas.

3. Cable Guide is the conduit located outboard at the pressure hull which guides the assembly from the pressure hull interface to the tow point. The Pressure Hull Interface is the main subsafe boundary located at the pressure hull which provides integrity when the hull shear/shut-off valve is closed. When the valve is opened the antenna assembly can pass through the hull into the conduit.

4. Tow/Exit Point is the point outboard of the pressure hull at which the antenna assembly exits the superstructure of the submarine.

At the beginning of the study, the current AN/BRA-18 and AN/BRA-24 systems were further analyzed. The three system concepts proposed in the CID response to RFP N00039-79-R-0131(S) were further developed. Additionally, two new concepts were developed and reviewed with the Program Sponsor. The three original and two additional concepts then became the basis for the tradeoff studies.

As the study progressed it became clear that while the system level issues were important, the goals and requirements had their greatest impact at the component level. This means that the success or failure of a system concept to deploy, retrieve and store the BCA in the operating confines of a submarine is really determined at the component level.

The components listed in Table 1 are the major components required in a DRSS and were allocated to the four study areas required in the SOW. These four areas were:

1. Deploy/Retrieve Mechanism
2. Cable Storage
3. Cable Guide
4. Tow/Exit Point

Additionally, we determined that most of these components were common to all of the system concepts (Refer to Table 1). These components were then further analyzed by looking at known or conceptual approaches to meeting the functional requirements of the components.

Table 1

System Concept Similarities

Study Area	Component	Concept A	Concept B	Concept C	Concept D	Concept E
1	Deploy/Retrieve	X	X	X	X	X
2	Cable Storage	X	X	X	X	X
3.1	Conduit/Guide Tube	X	X	X	X	X
3.2	Hull Shut-Off Valve	X	X	X	X	X
3.2	Fail Safe Shut-Off Valve	X	X	X	X	X
3.2	Cable/Antenna Element Shear Assembly	X	X	X	X	X
3.3	Manual Static Seal Valve	X	X	-	-	?
3.3	*Dynamic Seal, Variable Diameter*	X	-	-	-	-
3.3	Dynamic Seal, Fixed Diameter	-	X	-	-	X
3.3	Staging Tube Assembly	-	X	-	-	X
4.0	Tow Exit Point	X	X	X	X	X
-	Antenna Element Proximity Sensor	X	X	X	X	X
-	Cable Scope Sensor	X	X	X	X	X
-	Seal/Valve Position Sensor	X	X	X	X	X
-	Divertor Valve Assembly	-	-	-	-	X

This analysis was performed by translating the requirements, goals, and CID evaluation criteria into quantifiable terms when possible. The candidates which had the best scores as a result of this analysis were determined to be the best candidates for inclusion in the system concepts.

At this point, these candidates were incorporated into the system concepts. If this study had been an unconstrained maximization problem, then the best system would be a system comprised of all the best components. Since this study was not unconstrained, this was not the case. For example, it would be possible for each of the best components to meet the volume requirement and to have the summed system volume violate the requirement. This is because the volume requirement was a system level requirement which had to be considered at the component level, but could not be arbitrarily allocated at the component level. Therefore, some juggling of components was required to configure each of the system concepts.

3.2 COMPONENT TRADEOFF RESULTS

Before the system definition is addressed, it is useful to describe the best concepts from the component tradeoffs. When applicable, several concepts for each of these components were analyzed. The summary description of the best components is followed by a listing of all the components analyzed and the reference to the appropriate Volume II section and appendices which provide the detail description analysis, and component tradeoffs.

3.2.1 Deploy/Retrieve Mechanism

The best concept for a DRSS Deploy/Retrieve Mechanism was determined to be a single drum capstan. In principle, it is identical to the transfer mechanism used on the current AN/BRA-24 system. In implementation, it is considerably different. A concept sketch is shown in Figure 3.2.1.1. The key differences are the pinch roller assemblies and the motor. The pinch rollers provide the same containment function as do similar rollers in the current system. Their additional function is to articulate and allow passage as well as control of the large diameter antenna elements. The current motor is a key noise

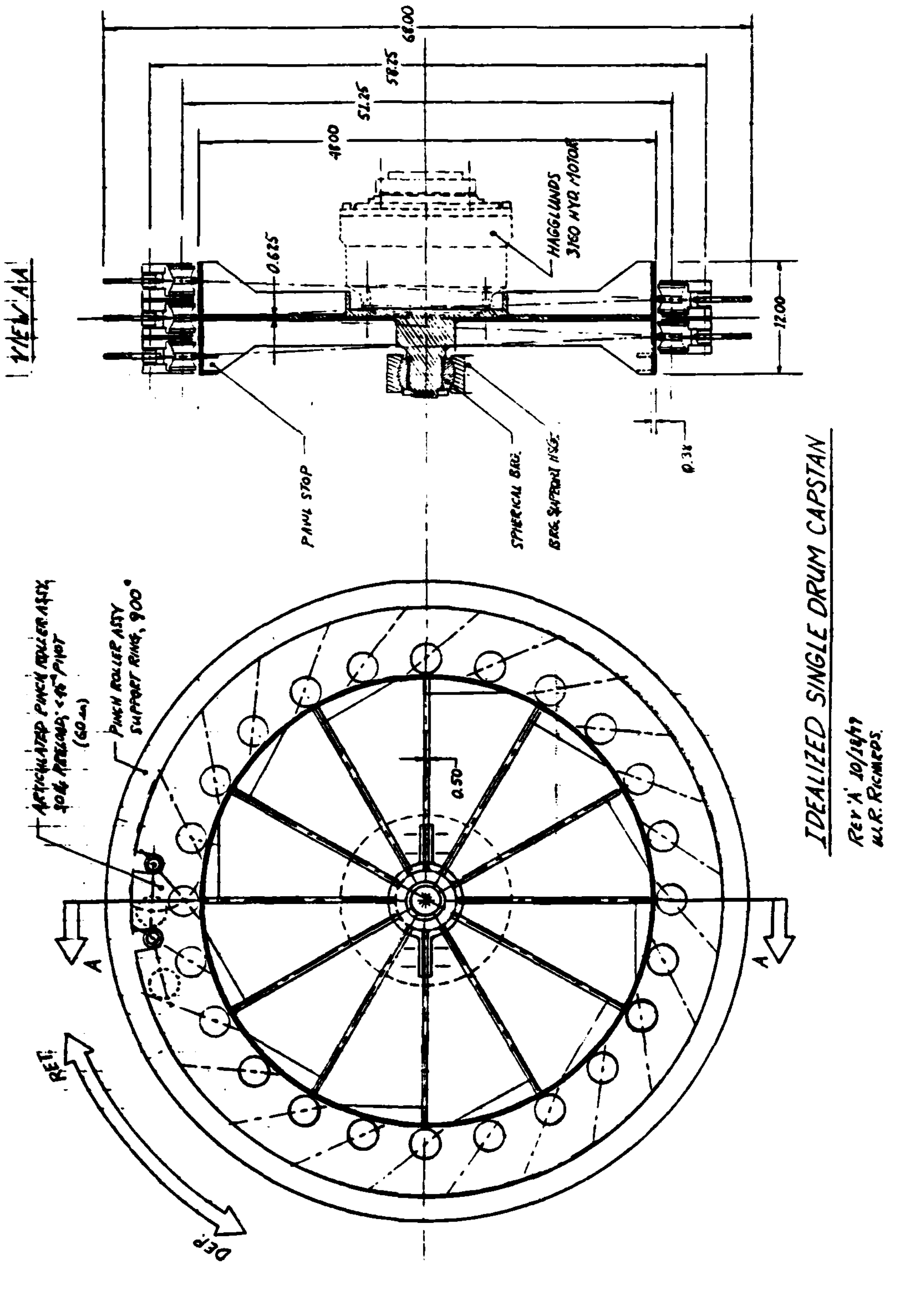


Figure 3.2.1.1. Idealized Single Drum Capstan

source on the submarine. Current technology extrapolation shows that this concept can meet the DRSS noise requirements. An additional benefit of this concept is its large diameter. This will ease antenna related bending, compressive and torsional problems.

3.2.2 Cable Storage

The best concept for BCA storage was determined to be simple drum with a constant torque hydraulic drive similar to our current design for Cable Handling Equipment for Towed Array Sonar (CHETSA) which will be installed the ballast tank of the 688 class submarine. The keys to cable storage are large enough bend radius so as to not harm the cable, low storage tension and effective utilization of space. The latter is important because a given length of a given diameter of antenna requires a minimum volume for storage. Thus, it is the form factor that is important. Figure 3.2.2.1 shows a CHETSA type storage assembly married to the previously described single drum capstan unit. The figure shows that this concept lends itself to an extemely effective packaging concept.

3.2.3 Cable Guide

We divided the cable guide into three separate areas. These were the conduit/guide tube, seals and valves.

The conduit/guide tube was analyzed with respect to the impact of coefficient of friction and total degrees of bend. Both of these factors require the outboard tension caused by dynamic load to be multiplied by a factor greater than one when determining the system inboard tension capability. Several options for reducing this multiplier effect were studied. Results of these studies provided an estimated performance envelope, evaluated maximum horsepower requirements and developed a two speed operational mode for optimizing system performance. The submarine hydraulic power supply was found to be adequate to meet all performance requirements and at least 50% of the performance goals. Therefore, defining the conduit/guide tube is a relatively straight forward materials and installation problem.

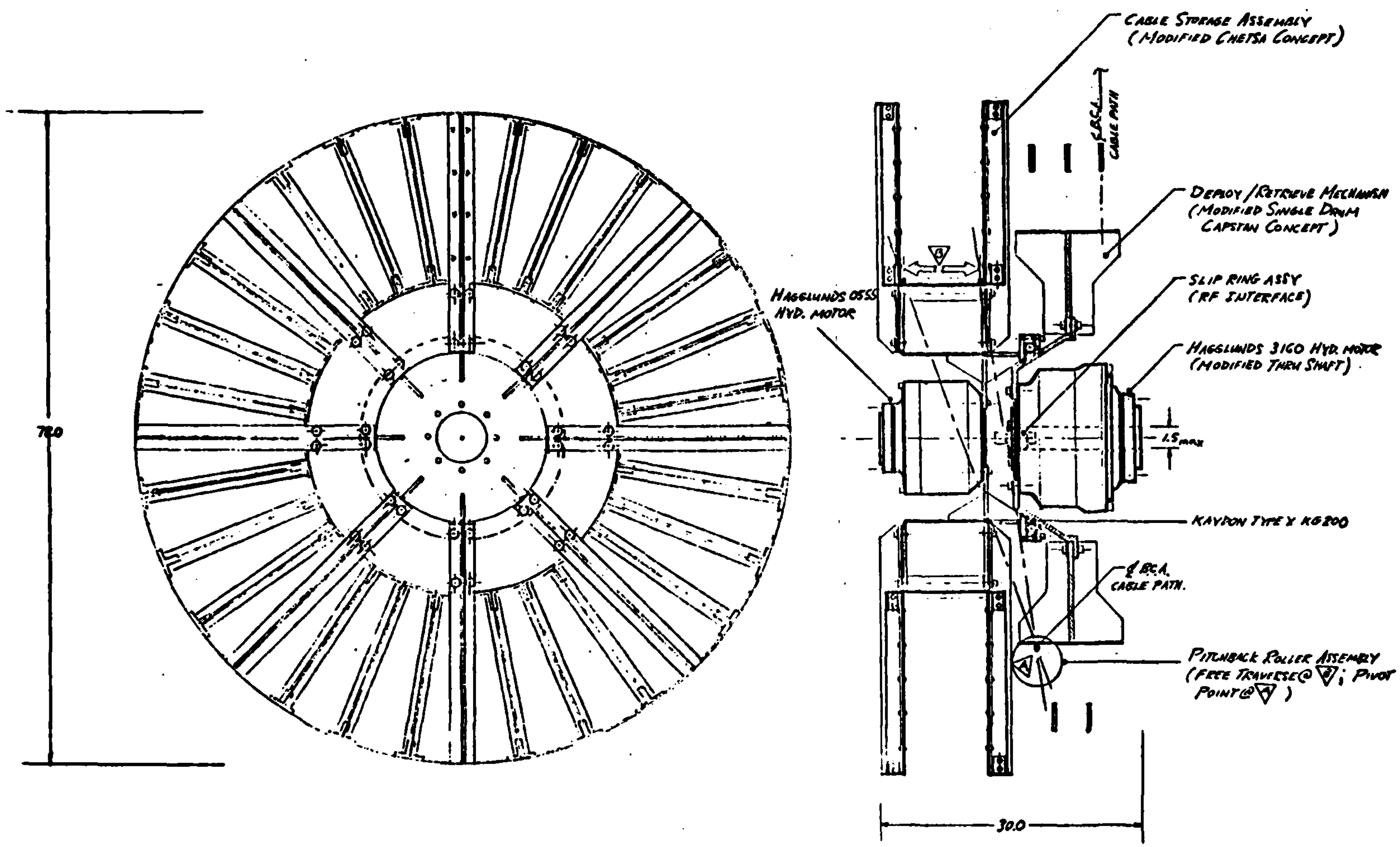


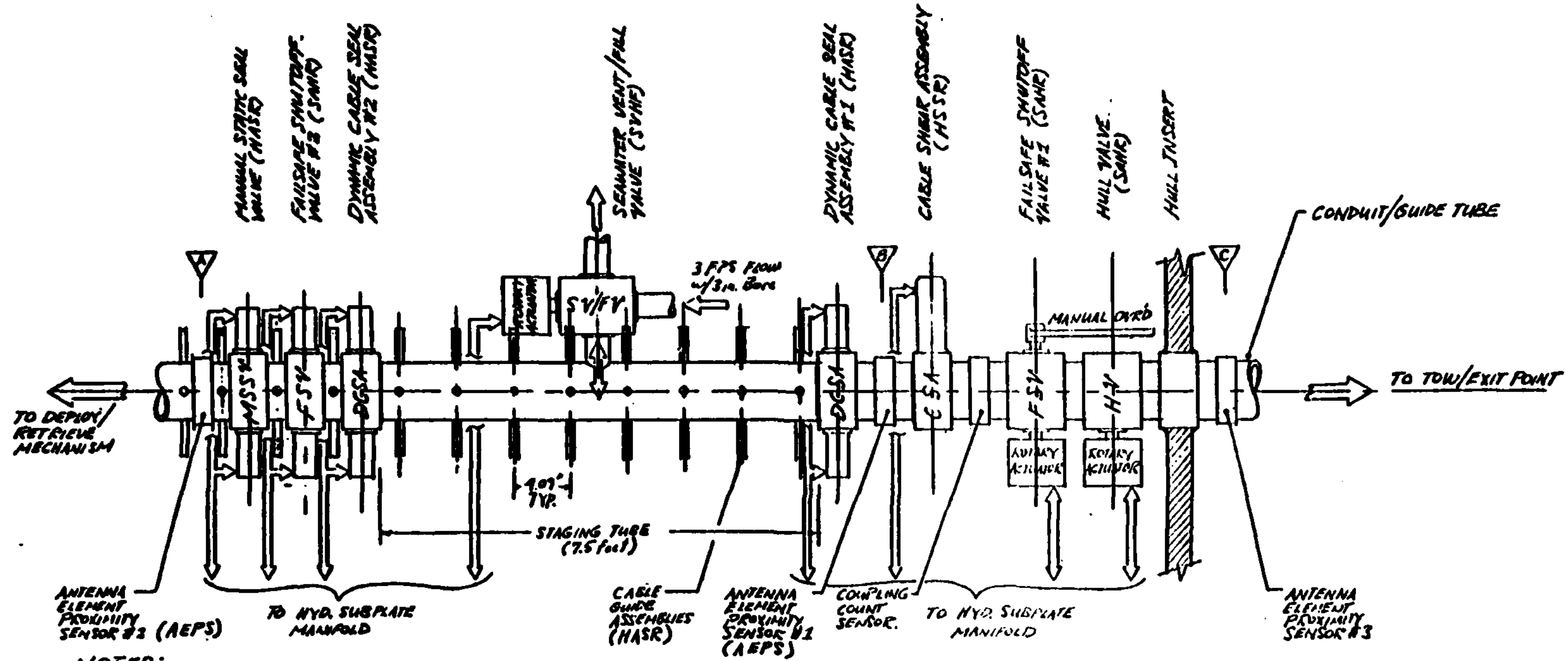
Figure 3.2.2.1. Cable Storage Assembly with Representative Packaging Layout, Modified for Tandem Installation Configuration

The seals and valves, however, are more complex. The key to our seals and valves studies was the definition of what we called a staging tube. Figure 3.2.3.1 shows the current concept configuration. The staging tube was specifically required so that the DRSS could deploy and retrieve the large diameter antenna elements over the full operating range of the submarine. The staging tube now includes those dynamic and static seals, failsafe and shear valves, and other hardware to meet the SUBSAFE requirements for DRSS.

The best concept for the dynamic seal is the fixed, two position, split seal configuration shown in Figure 3.2.3.2. A key element of this concept is the conformal wipers which must maintain contact pressures less than 10 psi on the buoyant cable antenna, adapt to cable diameter variances of ±.020 inches and prevent leakage at cable velocities of 400 FPM. Two approaches to this tandem seal configuration were developed. The first approach utilizes a pressure compensated high viscosity fluid within the annulus of the seals to prevent leakage. The second approach permits a minimum seawater leakage past the first seal into the annulus. The seawater is then piped into the submarine's drain system. These approaches work because the staging tube does not require a seal to function when an antenna element is passing through it. This is achieved through a sequence/interlock operation described in Table 3.2.3.1. Cable end termination passage operation is described in Table 3.2.3.2.

The best concept for the static seal is a permutation of the dynamic seal concept, and is shown in Figure 3.2.3.3. Resilient clamping surfaces are employed to generate a leaktight seal on the antenna cable.

The best concept for the hull valve and failsafe shut-off valve was found to be a short pattern ball valve similar to the one shown in Figure 3.2.3.4. Since the concept is an extrapolation from an existing valve, development risk is minimized. However, when the buoyant cable antenna (BCA) is deployed through the hull against sea pressure, column compressive loading is generated and the BCA will buckle if it is not supported. Current estimates show that the unsupported length must be less than six inches. This causes an



NOTES:

(1). MSSV engaged (clamped) only under static towing mode.
(2). FSV #2 & #1 engaged (closed) only when B.C.A. inboard of point A.
(3). HV & FSV #1 engaged (closed) if CSA is activated.
(4). DCSA #2 engaged (clamped) & DCSA #1 disengaged during Deploy or Retrieve mode with Staging Tube at equalized Seapressure ambient.
(5). DCSA #2 engaged (clamped) to permit Staging Tube Vent/Fill cycle for Antenna Element pressure equalization.
(6). CGA may be disengaged when B.C.A. scope deployed > 624 feet at ship speed > 15 knots, or scope/speed combinations sufficient to generate > 200 #s
(7) SV/FV operation interlocked with AEPS, DCSA, and AFSID sense. to ensure leaktight integrity during the Vent/Fill sequence.
(8) - HASR - Hyd. engage, Spring release
- SAHR - Spring engage, Hyd. release
- SVHF - Spring vent, Hyd. fill
- HSSR - Hyd. Shear, Spring release
(9) Valve, Seal position sensors not shown, would be for Control/Status interlock(s)

Figure 3.2.3.1. Staging Tube Configuration with Valves, Seals, C.G.A.s, and Sensors

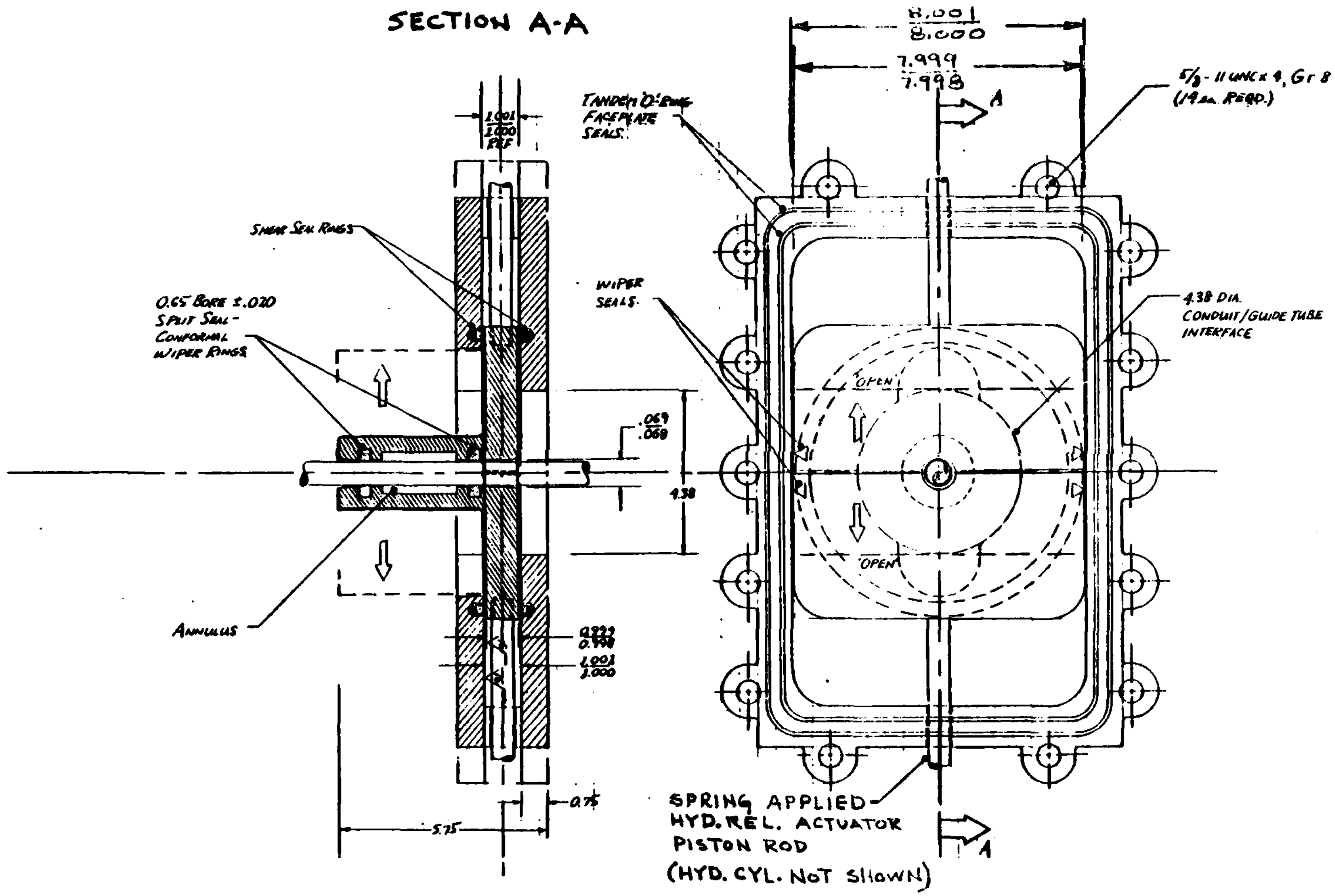


Figure 3.2.3.2. Dynamic Seal: Fixed, 2 Position, Split Concept Configuration

Table 3.2.3.1
Antenna Element Passage through Staging Tube Configuration

DEPLOYMENT Time, Sec.	DEPLOYMENT	RETRIEVAL Time, Sec.	RETRIEVAL
	Sense Antenna Element @'A' w/AEPS #2		Interlock Cable Scope Count @T.B.D. Feet, reduce to 1/10th Speed
12.0 ± 3.0	Stop	12.0 ± 3.0	Sense Antenna Element @'B' w/AEPS #1
(49.0)[1]	Vent Staging Tube (DCSA #1 activated)		Stop
(3.0)[1]	Open DCSA #2	28.5 ± 3.0	Start and Continue Retrieval. Decriment Scope by T.B.D. Feet @ 1/10th Speed
28.5 ± 3.0	Start and Continue Deployment Increment Scope by T.B.D. Feet @ 1/10th Speed		
1.5	Stop	1.5	Stop
3.0	Close DCSA #2	3.0	Close DCSA #1
49.0	Fill Staging Tube, Equalize Antenna Element @ Ambient Seapressure	49.0	Vent Staging Tube, Equalize to Ambient Atmosphere
3.0	Open DCSA #1	3.0	Open DCSA #2
12.0 ± 3.0	Start and Continue Deployment @200 → 400 FPM	12.0 ± 3.0	Start and Continue Retrieval @200 → 400 FPM
109.0±9.0		109.0±9.0	

NOTES:

(1) (49.0) and (3.0) are not included if DCSA #1 employed prior to Antenna Element sense at 'A'. A 2nd Antenna Element would require these two steps.

(2) The Staging Tube Vent/Fill time of 49.0 seconds is based upon the following: 7.5 ft. long annulus, 5.0 in. I.D. w/4 in. O.D. Antenna Element 4.0 ft. long; Estimated Displacement Volume required equals < 4.5 Gallons; the Vent/Fill line bore of 3.0 in., with seawater velocity ≤ 3.0 FPS provides rate of .092 GPS; 4.5 Gallons/.092 GPS = 49.0 seconds.

Table 3.2.3.2
Cable End Termination Passage through Staging Tube Configuration

DEPLOYMENT

Time, Sec.	
4.5	Power up, Disengage Pawl & Start Deployment @1/10th Speed
	Sense Cable End Termination @'A' w/AEPS #2
1.5	Stop
3.0	Open FSV #2
	Start @1/10th Speed
28.5 ± 3.0	Passage of Cable End Termination through DSA #2 Staging Tube & DSA #1
	Sense Cable End Termination @'B' w/AEPS #1, Activate DSCA #1
1.5	Stop
(49.0)[1]	Fill Staging Tube, Equalize @Ambient Seapressure
3.0	Open FSV #1 & HV
12.0 ± 3.0	Start & Deploy @200 → 400 FPM until Desired Scope
54.0 ± 6.0	

RETRIEVAL

Time, Sec.	
	Power up, Disengage Pawl, MSSV & Start Retrieval @200 → 400 FPM
	Interlock Cable Scope Count @T.B.D. Feet, reduce to 1/10th Speed
12.0 ± 3	
	Sense Cable End Termination @'B' w/AEPS #1
1.5	Stop
3.0	Close HV & FSV #1
(49.0)[1]	Vent Staging Tube, Equalize to Ambient Atmosphere
	Start @ 1/10th Speed
28.5 ± 3.0	Passage of Cable End Termination through DCSA #1 Staging Tube and DCSA #2
1.5	Sense Cable End Termination @4' w/AEPS #2. Stop.
3.0	Close FSV #2, Deactivate DCSA #1
	Continue Retrieval @1/10th Speed until Scope equals 0
4.5	Stop, Engage Pawl & Power Down
54.0 ± 6.0	

NOTES:

(1) The (49.0)* seconds is not included in the total passage time if DSCA #1 is employed as the operational dynamic seal.

(2) Optimization of the sequence and representative times must be made through further Detailed Definition. The above operational modes are <u>representative only</u>!

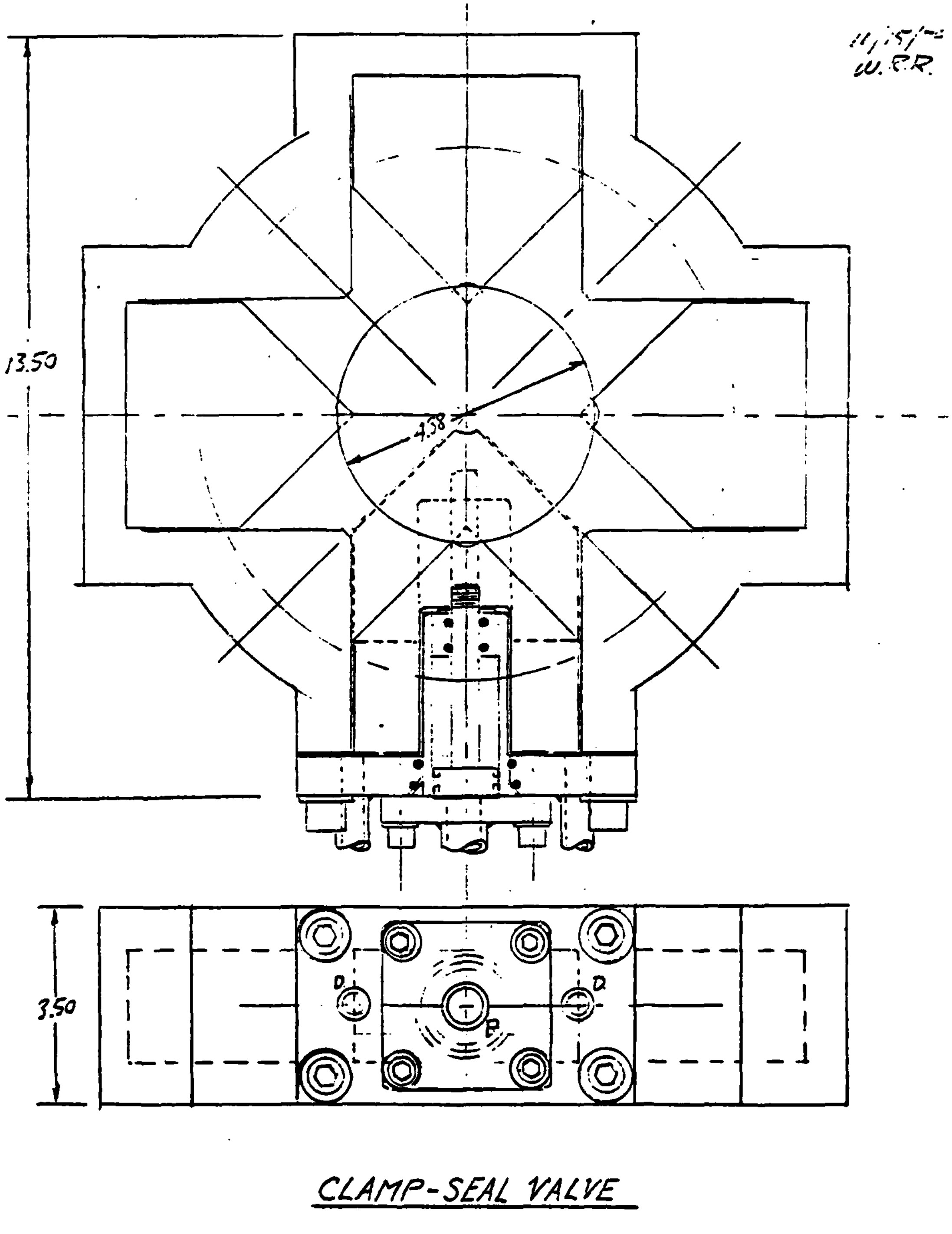
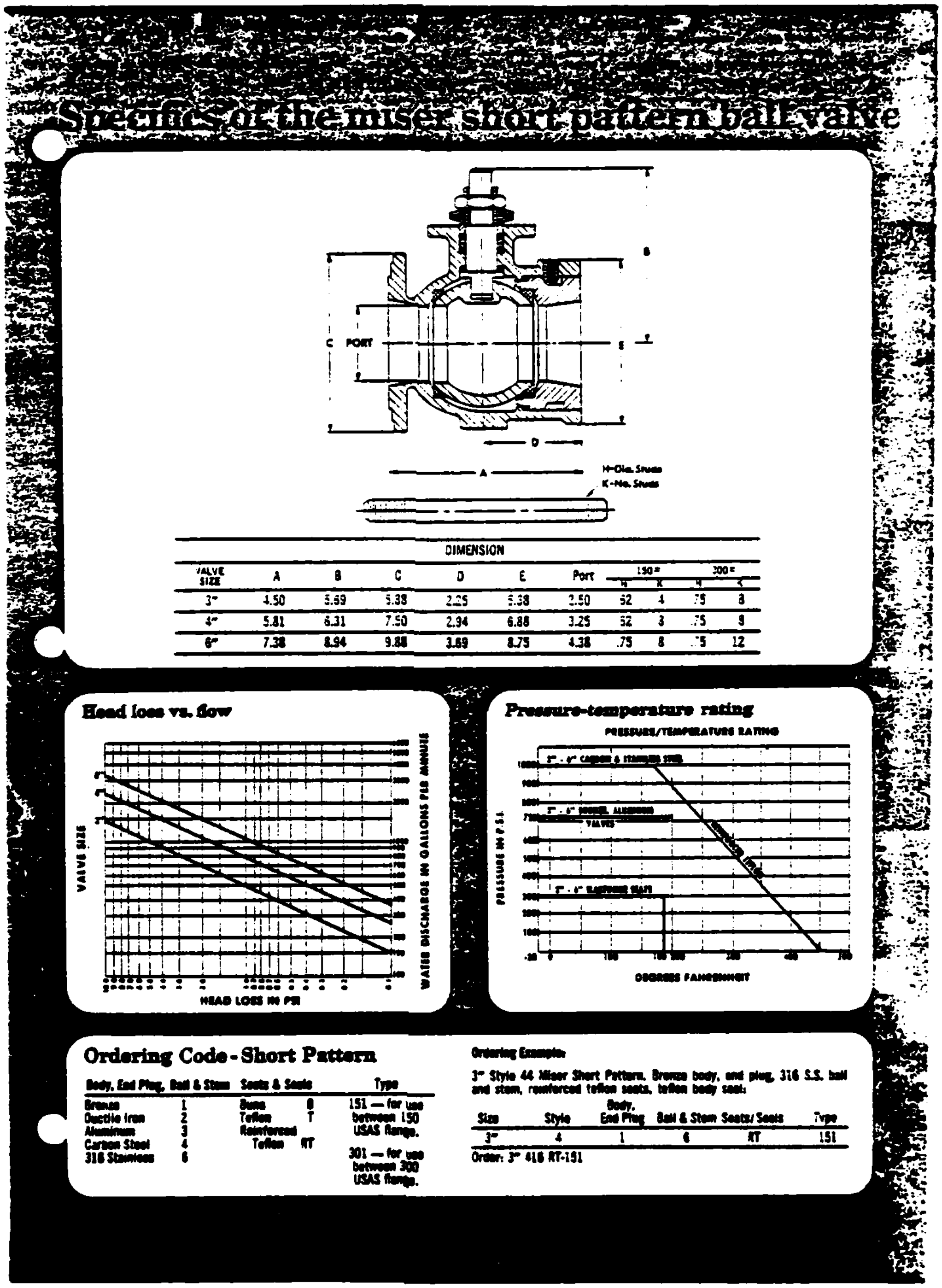


Figure 3.2.3.3. Clam-Seal Valve Concept



Specifics of the miser short pattern ball valve

DIMENSION										
VALVE SIZE	A	B	C	D	E	Port	150# H	150# K	300# H	300# K
3"	4.50	5.69	5.38	2.25	5.38	2.50	62	4	75	8
4"	5.81	6.31	7.50	2.94	6.88	3.25	62	3	.75	8
6"	7.38	8.94	9.88	3.69	8.75	4.38	.75	8	.75	12

Ordering Code - Short Pattern

Body, End Plug, Ball & Stem		Seats & Seals		Type
Bronze	1	Buna	B	151 — for use between 150 USAS flange.
Ductile Iron	2	Teflon	T	
Aluminum	3	Reinforced Teflon	RT	
Carbon Steel	4			301 — for use between 300 USAS flange.
316 Stainless	6			

Ordering Example:

3" Style 44 Miser Short Pattern. Bronze body, end plug, 316 S.S. ball and stem, reinforced teflon seats, teflon body seal:

Size	Style	Body, End Plug	Ball & Stem	Seats/Seals	Type
3"	4	1	6	RT	151

Order: 3" 416 RT-151

Figure 3.2.3.4. Short Pattern Ball Valve Concept

obvious problem when the valves must be sized to pass six inch diameter antenna elements. That is, the unsupported distance within the valve bore is greater than six inches. Further definitization is required in this area.

A shear valve such as the one shown in Figure 3.2.3.5 will not have this problem.

The BCA buckling problem can occur any place in the DRSS where there are unsupported BCA runs. This necessitated the conceptualization of the cable support assemblies shown in Figure 3.2.3.6. At a minimum, these cable support assemblies will be required inside the staging tube. These assemblies will be retracted during the passage of antenna elements.

The seals, valves and cable support assemblies which comprise the staging tube are high risk areas which require further definition and risk assessment.

3.2.4 Tow/Exit Point

The key to the tow/exit point is meeting the structural requirements without impacting submarine hydrodynamics. Figure 3.2.4.1 shows the current concept.

3.2.5 References

The component concepts, and the reference to Volume II, are as follows:

1. Deploy/Retrieve Mechanism -- Refer to Vol. II, Section I
   - Linear Traction
   - Clamp Traction
   - Single Drum Capstan
   - Laminar Fluid
   - Direct Windup
2. Cable Storage -- Refer to Vol. II, Section 2
   - CHETSA
   - W/Levelwind
   - Pressure Proof Access Trunk
   - Barrel Stuffing

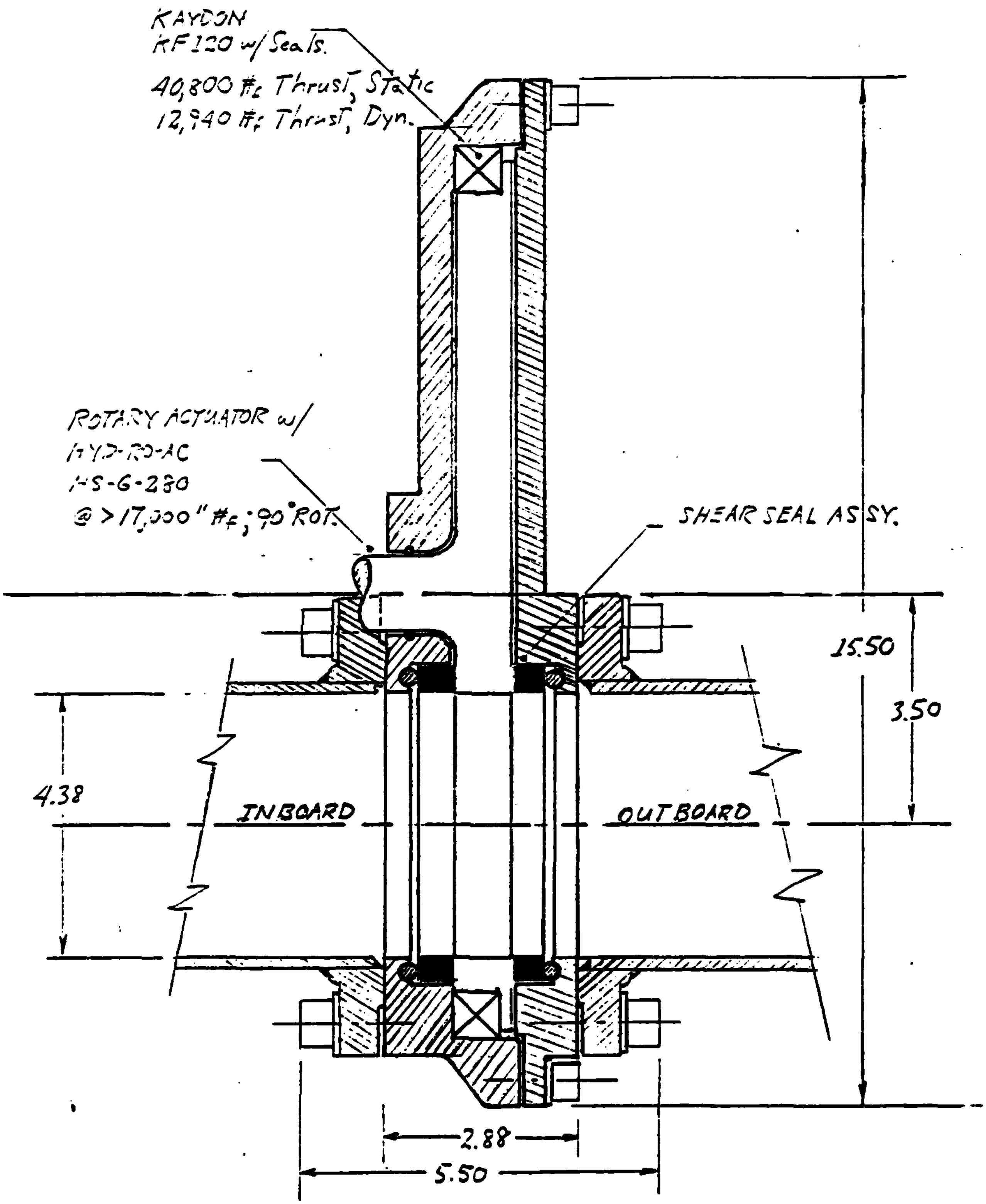


Figure 3.2.3.5. Shear-Seal Rotary Valve

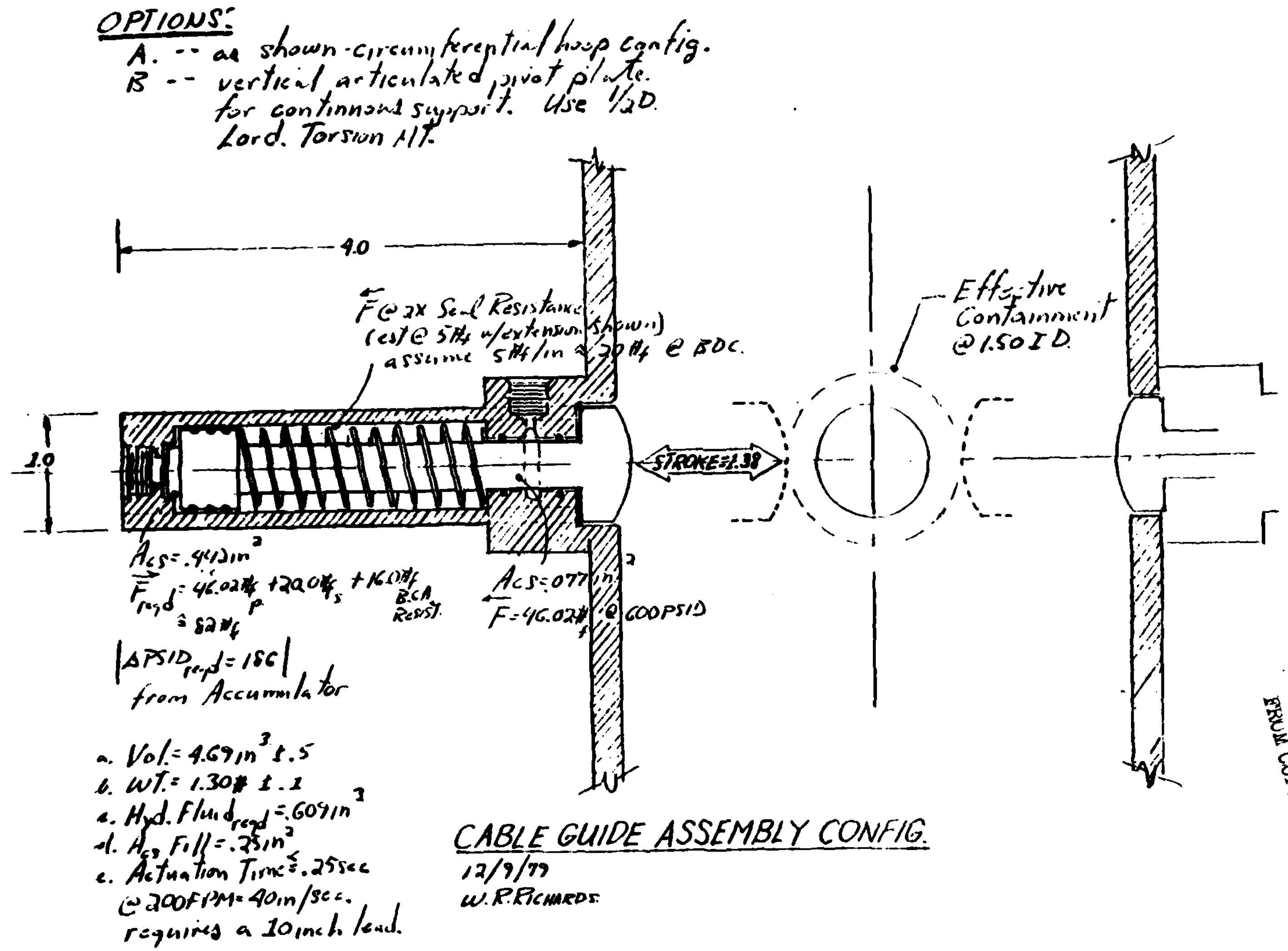


Figure 3.2.3.6. Cable Support Assembly Concept

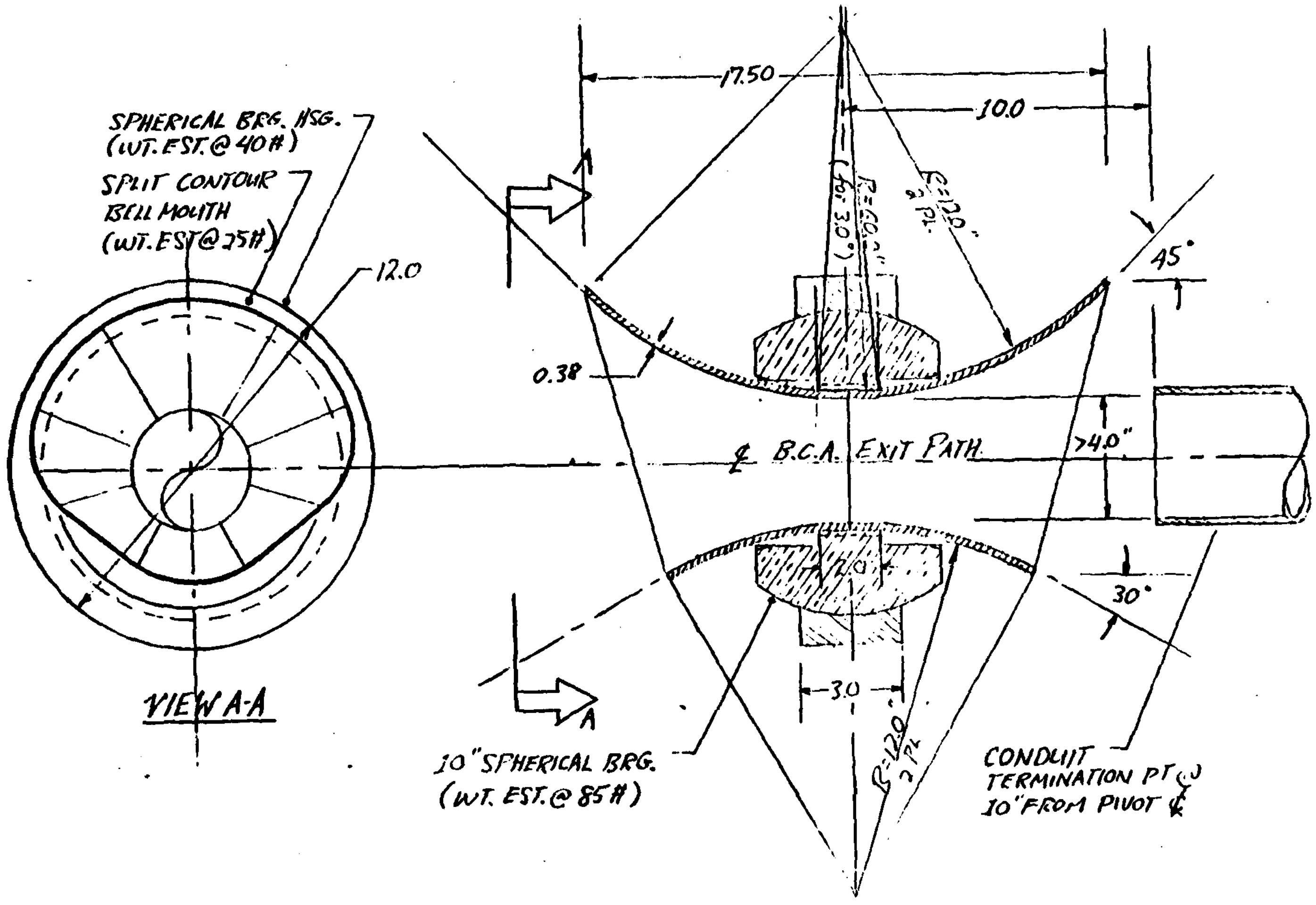


Figure 3.2.4.1. Articulated Bellmouth, Tow/Exit Point

3. <u>Conduit/Guide Tube</u> - Refer to Vol. II, Section 3, Part 1

   <u>Valves</u> -- Refer to Vol. II, Section 3, Part 2

   - Ball Valve
   - Shear-Seal Rotary
   - Clamp-Seal

   <u>Seals</u> -- Refer to Vol. II, Section 3, Part 3

   - Dynamic, Variable, Articulated Segment
   - Dynamic, Variable, Bladder
   - Dynamic, Fixed 2- Position, Split
   - Dynamic, Variable, Iris

4. <u>Tow/Exit Point</u> -- Refer to Vol. II, Section 4

Additionally, detail appendices were developed. These appendices contain the engineering notes and detail analysis to support the component trade studies. These appendices are contained in Volume II, and are listed below for reference.

- Appendix A - Idealized Linear Traction Device
- Appendix B - Idealized Clamp Traction Device
- Appendix C - Idealized Single Drum Capstan
- Appendix D - Idealized Laminar Fluid Device
- Appendix E - Idealized Direct Windup Assy
- Appendix F - Structureborne Noise Analysis
- Appendix G - Cable Analysis Tests
- Appendix H - B.C.A. Depth vs. Speed-of-Advance Computer Analysis
- Appendix I - B.C.A. Bending - Storage Assembly/Capstan Characterization
- Appendix J - Storage Assembly - CHETSA Concept
- Appendix K - Storage Assembly - w/Levelwind
- Appendix L - Storage Assembly - Pressure Proof Access Trunk
- Appendix M - Storage Assembly - Barrel Stuffing
- Appendix N - Characterization of Dynamic Seal Leakage

- Appendix O - Characterization of Dynamic Seal Heat Transfer
- Appendix P - Dynamic Seal, Variable, Articulated Segment
- Appendix Q - Dynamic Sea, Variable, Bladder
- Appendix R - Dynamic Seal, Fixed, Two Position, Split
- Appendix S - Dynamic Sea, Variable, Iris
- Appendix T - Hardware/Manufacturers Brochures
- Appendix U - Data Base Tabulation

3.3 SYSTEM SYNTHESIS AND ANALYSIS

The following paragraphs establish the System Concept(s) for a Deploy/Retrieve/Storage System (DRSS) for present and future Radio Frequency Buoyant Cable Antenna Systems on SSN and SSBN submarines, and provide the basis for investigation of performance, installation and cost tradeoffs. These concepts functionally replace the antenna transfer mechanism, antenna storage reel, pressure hull interface, conduit and tow/exit point presently installed on submarines as part of the existing AN/BRA-18 and AN/BRA-24, systems.

The five separate System Concept Configurations generated for this tradeoff study are as follows:

Concept A - For Handling Moderate Diameter Antenna Elements (1/2 to 1 inch)

Concept B - For Handling Large Diameter Antenna Elements (up to 4 inches)

Concept C - Enclosed in Pressure Proof Access Trunk

Concept D - Located in Main Access Trunk

Concept E - Located in Aft Main Ballast Tank

A detailed description of each of the above candidates is found in the following paragraphs.

3.3.1 Concept A

3.3.1.1 General Description

- For handling moderate diameter (.50 → 1.00 inch) cables and antenna elements.
- The major problems and risk areas associated with this concept are the development of two key components (Dynamic Seal and Transfer Mechanism) and allotment of space for the Cable/Antenna Element Storage Assembly. Although it is conveniently depicted in Figure 3.3.1.1 component configurations/layout might need to be changed to fit available space.

3.3.1.2 Detail Definition

The system functional interrelationships are shown in Figure 3.3.1.2.1, with a detail component breakdown provided in Figure 3.3.1.2.2. The components/subsystems have been selected from tradeoff analyses made during the component level studies presented in Volume II.

3.3.1.3 System Operation

Deploy Operation (Refer to Figure 3.3.1.1)

A. Hull Valve (4) and Manual Static Seal (7) are opened to the full bore of the conduit. Control Console (11) indicates "open".

B. Cable is pushed through Dynamic Seal (8) with Transfer Mechanism (9).

C. Fail-Safe Static Seal (6) is opened to flood inboard conduit with seawater and equalize pressure across fail-safe static seal. Control Console (11) indicates "open".

D. Transfer Mechanism (19) pushes cable through fail-safe static seal and through Conduit (3) at slow speed until Cable Antenna Element Proximity Sensor (2) indicates presence of cable at Tow Point Exit (1).

E. Transfer Mechanism (9) then deploys cable at high speed until antenna element approaches Dynamic Seal (8). Transfer mechanism is slowed as

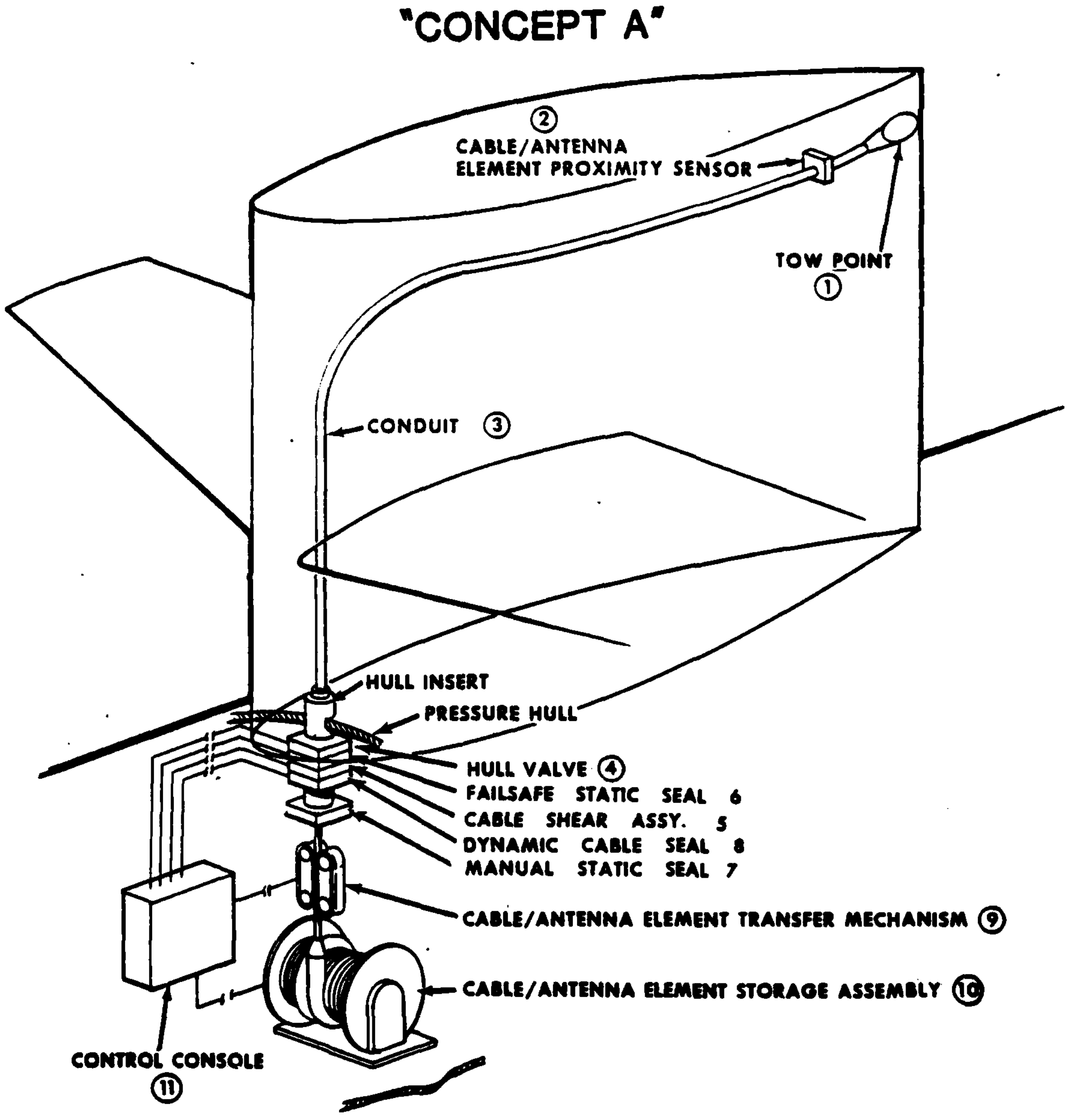


Figure 3.3.1.1. System Concept A

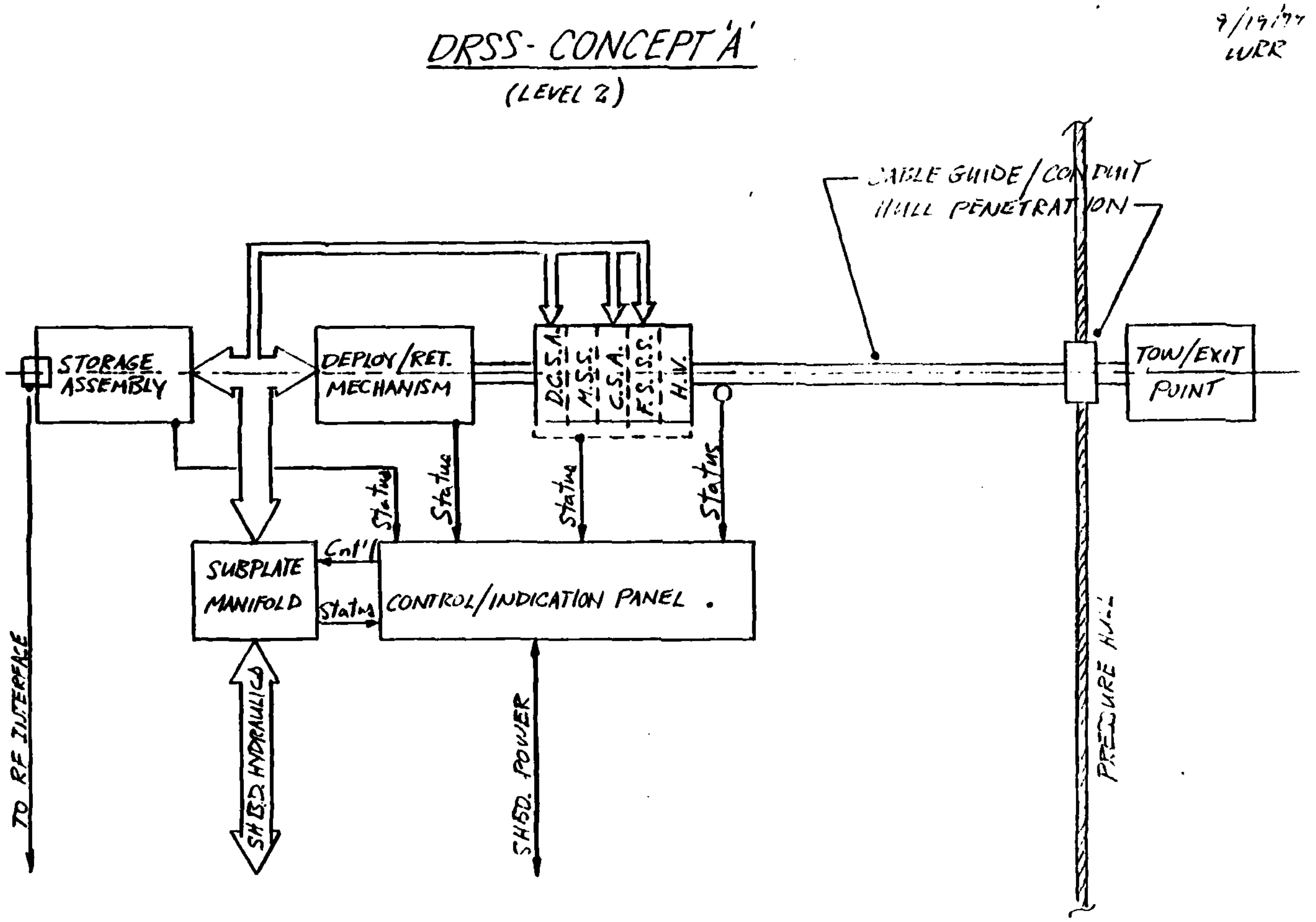


Figure 3.3.1.2.1. Concept A Functional Interrelationship

Component/Subsystem	Vol, FT^3	Wt. #
• Bladder or Iris Dynamic Seal, Var. Dia.	.50	< 50
• Manual Static Seal Valve, Fixed, 2-Posn.	.50	< 50
• Dep./Ret. Mechanism - Single Drum Capstan	25.21	2300
(use Aluminum, const.)	less	760
• Storage Assembly - CHETSA Concept	42.85	1887
(use Aluminum, const.)	less	987
• Failsafe Shutoff Valve (2" Ball Valve)	.50	< 50
• Cable/Antenna Element Shear Assembly (similar to BRA-24)	.12	< 50
• Hull Shutoff Valve (2" Ball Valve)	.50	< 50
• Antenna Element Proximity Sensors (2 ea) (similar to CHETSA)	.125	2.5
• Cable Scope Sensor (2 ea) (similar to CHETSA)	.125	2.5
• Seal/Valve Position Sensor (5 ea)	.25	5.0
• Conduit - Guide Tube, max 1.50 ID x 30' Lg.	.65	150
- (plus Outboard Sheave 48 in. OD x 2" wide)	2.09	250
• Tow/Exit Point, 1.50 Bellmouth Bore	< .84	75.0
	74.26	3175.0

Operational/Performance Capability Summary

- .50 → 1.00 dia. Buoyant Cable Assembly
- 4125$\#_f$ Dynamic Load
- 5000 ft Cable Storage
- W/2-Speed Opn'l Mode > 20 knots @200 FPM, 5000 ft scope
  & > 20 knots @400 FPM, 2500 ft scope
- MTBF ≥ 645 Hrs; Deploy/Retrieve Cycle Time equals 16.7 minutes.

Figure 3.3.1.2.2. Concept A Detail Definition Summary

antenna element is taken through automatically expanded transfer mechanism and pushed through automatically expanded Dynamic Seal (8).

F. Transfer Mechanism (9) deploys cable at high speed when Cable/Antenna Proximity Sensor (2) indicates antenna element has passed the Tow Point (1).

G. When deployment is complete, Manual Static Seal (7) is closed to seal around cable for long term towing with cable/antenna trailing.

H. Cable is tensioned against cable/antenna element storage assembly. Cable/antenna element storage assembly is locked to take entire 6000 to 10,000 lb. tension load during towing.

Retrieval Operation

The retrieval operation is the reverse of the deployment operation except that Cable/Antenna Element Proximity Sensor (2) senses the approach of the antenna element and automatically slows the Transfer Mechanism (9) to allow controlled retrieval of the antenna element.

3.3.1.4 Conclusion

3.3.1.4.1 Risk Areas

(a) A Dynamic Seal-Variable, to accommodate changing cable diameters with zero leaks.

(b) A Transfer Mechanism which resolves present "introduced" system major problem areas.

3.3.1.4.2 Performance

PROs	CONs
• Low Degree-of-Difficulty	• Does not provide capability to handle 4" Dia x 4 ft. long Antenna Elements
• Extension of State-of-the-Art	
• Should not require extensive submarine modifications.	• At 180 psid, w/1.38 Dia. Antenna Element — a force of 209# is generated against the differential area as

- Conduit Sizes; Valves & Seals Size; and Transfer Mechanism Config. Reqts. are all minimized.

- Constant inhaul/outhaul speed capability.

it passes through the dynamic seal. Specified BRA-24 limits to column loading indicate buckling on a 6.5" cable @80$\#_f$

Concept A is not responsive to SOW Requirement #11. This is a major system deficiency in this DRSS concept, permitting only a maximum diameter of 1 in. vs the 4 in. required.

3.3.2 Concept B

3.3.2.1 General Description

- For handling large diameter (4.0, 6.0 inch) antenna elements with either .50, 1.00 inch or .65 inch buoyant cable.
- The major problems and risk areas associated with this concept are the development of three key components (Dynamic Seal, Transfer Mechanism, and a Staging Tube) and allotment of space for the Cable/Antenna Element Storage Assembly.
- The Dynamic Seal must seal against a constant diameter cable, but must open its bore to 4.0 to 6.0 inches when not used for sealing.
- The Transfer Mechanism must be capable of adjusting its grip to accept the large variance in cable diameters.
- The staging tube must equalize pressure across the differential cross-sectional areas of the cable assembly in order to permit deployment against ambient sea pressure resistance.
- Although it is conveniently depicted in Figure 3.3.2.1, the configuration must fit available space.

3.3.2.2 Detail Definition

The system functional interrelationships are shown in Figure 3.3.2.2.1, with a detail component breakdown provided in Figure 3.3.2.2.2. The components/subsystems have been selected from tradeoff analyses made during the component level studies present in Volume II.

Figure 3.3.2.2.3 depicts an assembly approach directed towards optimization of envelope requirements. A bedplate interfaces each drive motor to a ships foundation. The assembled structure is approximately six feet wide by three feet deep by six feet high and weighs approximately 2500#. The structure is designed to be assembled within the pressure hull, with the largest subassembly elements capable of passing through the 26 in.

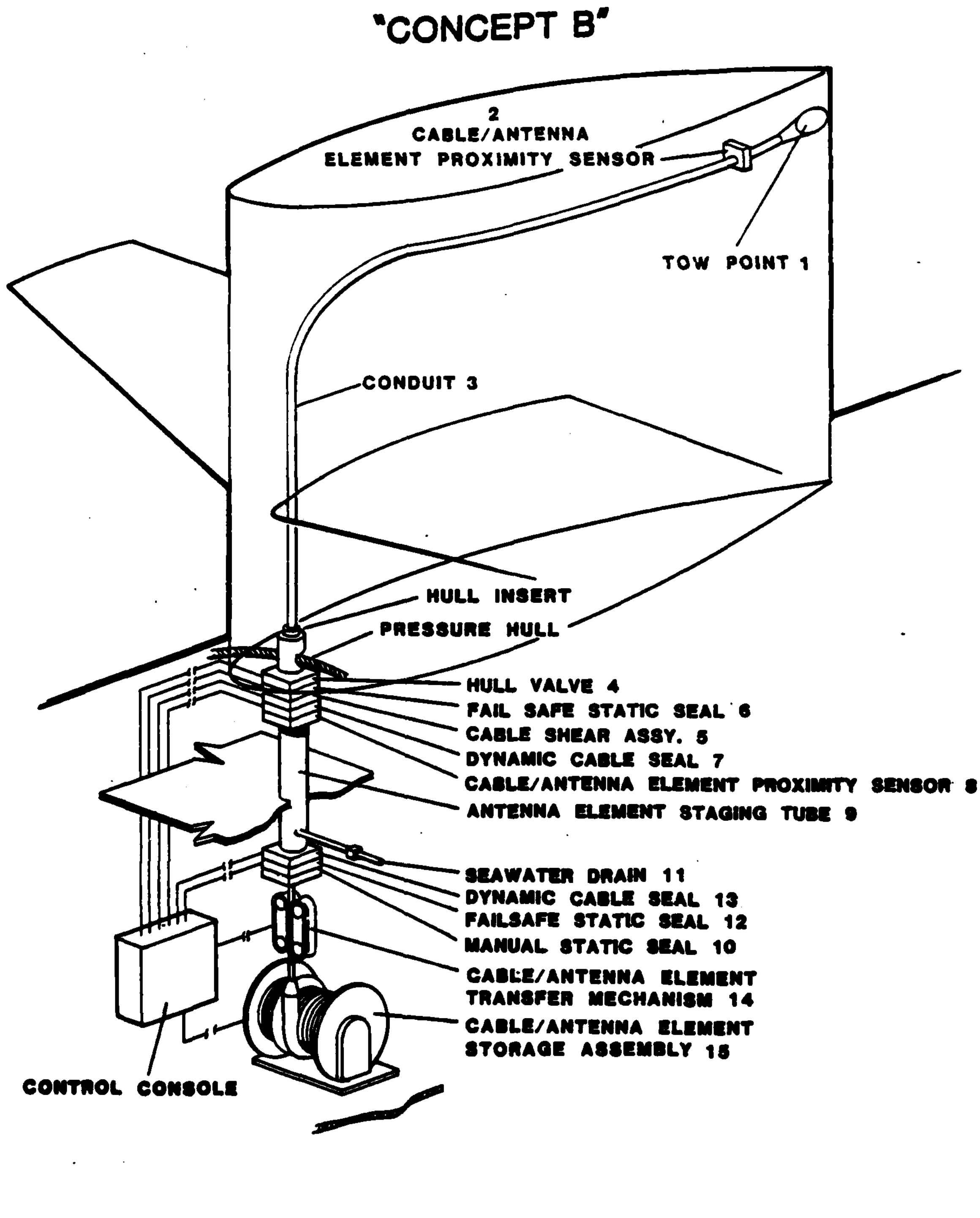


Figure 3.3.2.1. System Concept B

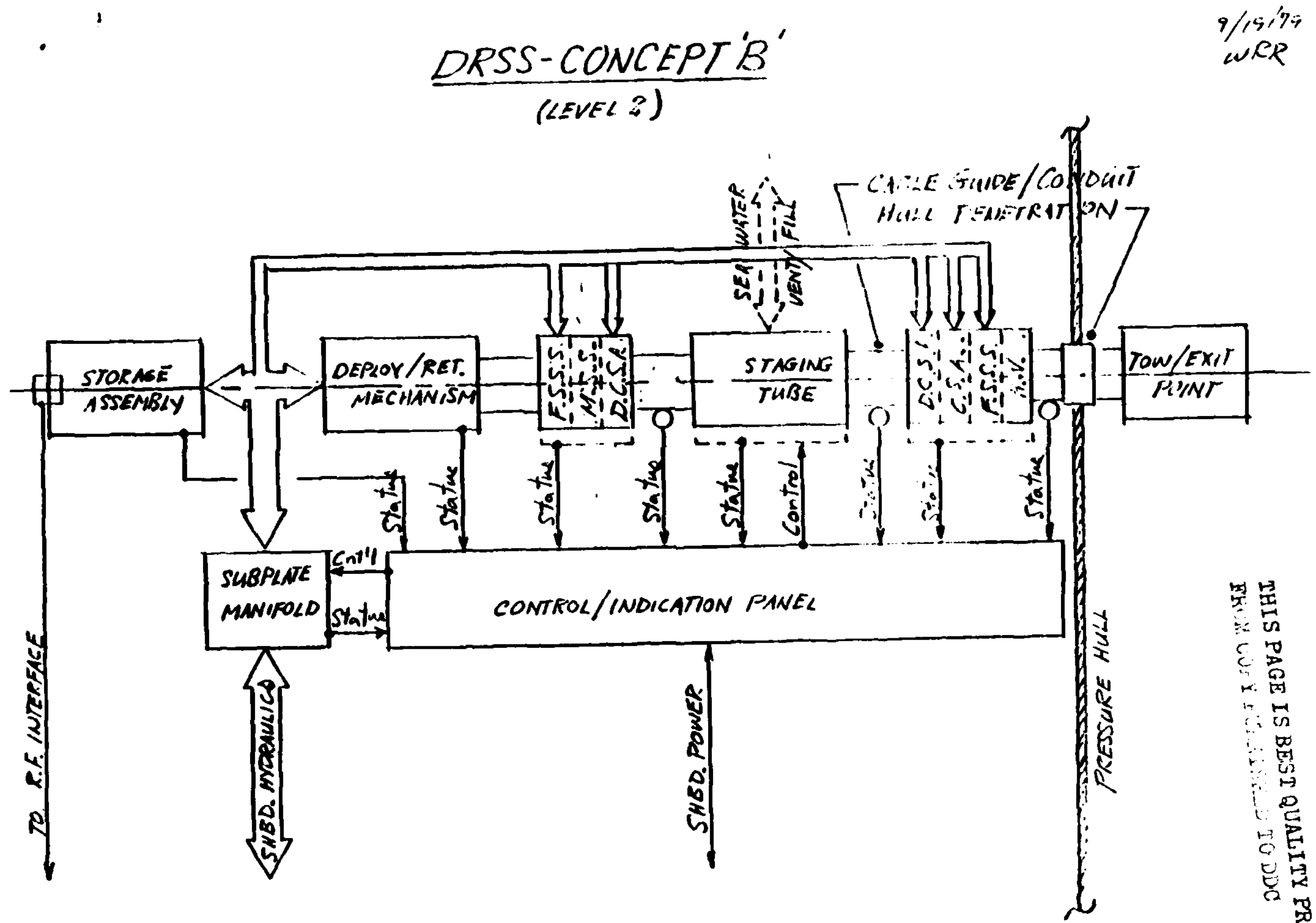


Figure 3.3.2.2.1. Concept B Functional Interrelationship

Component/Subsystem	Vol, FT^3	Wt. #
• Dynamic Seal, Fixed, 2-Position (2 ea)	1.0	200
• Manual Static Seal Valve, Fixed, 2-Posn.	.50	100
• Dep./Ret. Mechanism - Single Drum Capstan	25.21	2300
(use Aluminum const)	less	760
• Storage Assembly - CHETSA Concept	42.85	1887
(use Aluminum const)	less	987
• Failsafe Shutoff Valve (6" Ball Valve) (2 ea)	1.0	200
• Cable/Antenna Elements Shear Assembly (similar to BRA-24)	.50	100
• Hull Shutoff Valve (6" Ball Valve)	.50	100
• Antenna Element Proximity Sensor (2 ea) (similar to CHETSA)	.125	2.5
• Cable Scope Sensor (2 ea) (similar to CHETSA)	.125	2.5
• Seal/Valve Position Sensor (7 ea) (Limit Switch Configuration)	.35	7.0
• Conduit/Guide Tube 4.38 ID x 20' Lg	2.60	262
- (plus Outboard Sheave 48 in OD x 5" wide)	5.23	350
- (plus Cable Centering Guide Assys @25#/assy & 10 in^3/assy x 58 assys)	.30	145
- (plus Staging Tube 7.5" Lg x 4.88 in OD)	.98	98
- (plus Seawater Vent/Fill Valve)	.50	100
• Tow/Exit Point, 4.38 Bellmouth Bere	.84	150
	82.61	4257.0

Operational/Performance Capability

- .65→4.0 dia. Buoyant Cable Assembly
- $4125\#_f$ Dynamic Load
- 5000 ft Cable Storage
- W/2-Speed Opn'l Mode - > 20 knots @200 FPM, 5000 ft scope & > 20 knots @400 FPM, 2500 ft scope
- MTBF ≥ 432 Hrs; Deploy/Retrieve Cycle Time equals 34.9 minutes w/7 ea 4.0 in Dia. x 4 ft Long Antenna Elements

Figure 3.3.2.2.2. Concept B Detail Definition Summary

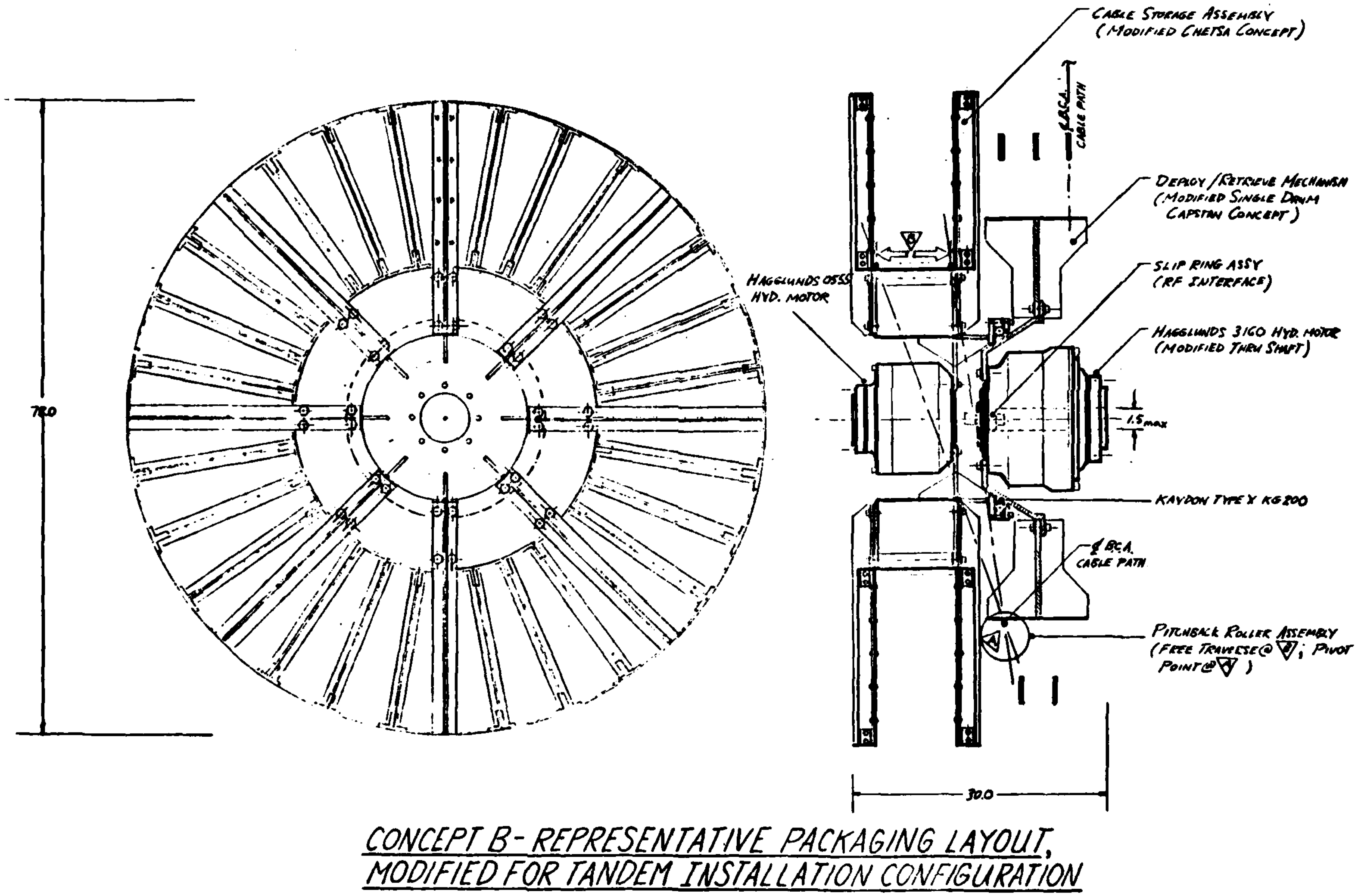


Figure 3.3.2.2.3. Concept B - Representative Packaging Layout, Modified for Tandem Installation Configuration

diameter main access trunk. Unique characteristics of the packaging approach are: (1) the Slip Ring Assembly is installed in a modified through shaft Hagglunds 3160 hydraulic motor; (2) BCA cable path is a continuous spiral of 2.5 wraps on the single drum capstan to point A, which provides an additional half wrap on the free traverse pitchback roller assembly to point B on the cable storage assembly.

The single drum capstan provides up to 4125# dynamic load capacity, with the storage assembly providing low windup tension. The configuration, without shock absorption between the bedplates and their respective ship foundations, could sustain up to a 25G shock load.

In order to permit the Deploy/Retrieve Mechanism to deploy the BCA through the staging tube and pressure hull against ambient sea pressure, the staging tube must be as close as possible to the single drum capstan to prevent cable buckling. The cable guide assemblies must be capable of effecting cable support to within 4 inches of the last point of contact generated by a pinch roller assembly.

A conceptual layout of the staging tube is depicted in Figure 3.3.2.2.4.

From the staging tube, the BCA passes through the conduit/guide tube to the tow/exit point, Figure 3.3.2.2.5, located in the aft top point of the sail.

3.3.2.3 System Operation

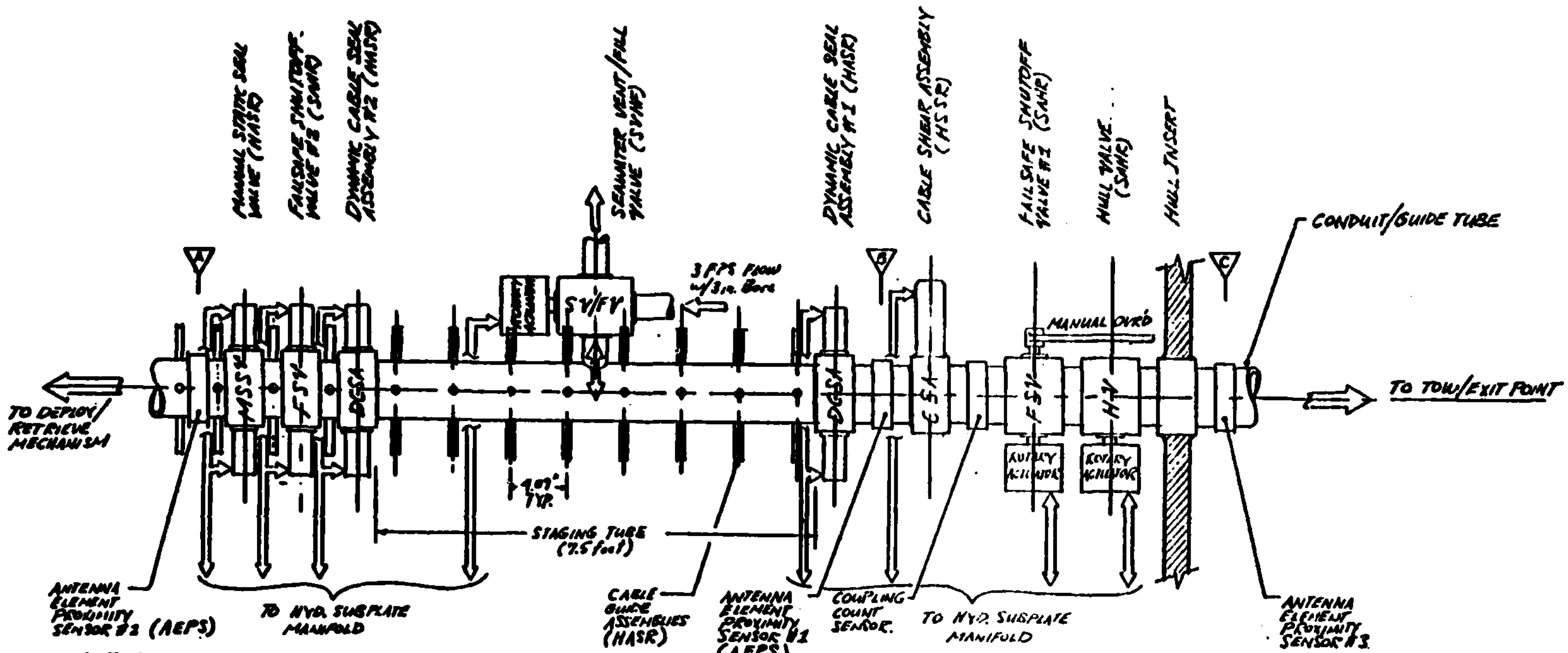
Deploy and retrieve sequence for antenna element passage through the staging tube is shown in Figure 3.3.2.3.1 and for cable end passage through the staging tube is shown in Figure 3.3.2.3.2.

3.3.2.4 Conclusion

3.3.2.4.1 Risk Areas

(a) A Dynamic Seal to accommodate the minimum "running diameter" -capable of opening - and permit passage of the Antenna Element into the Staging Tube. (Interlock/Sequencing vs. Sensors is essential).

(b) A Transfer Mechanism which resolves present "introduced" system major problem areas.



NOTES:

(1). MSSV engaged (clamped) only under static towing mode.
(2). FSV#2&#1 engaged (closed) only when B.C.A. inboard of point A.
(3). HV & FSV#1 engaged (closed) if CSA is activated.
(4). DCSA#2 engaged (clamped) & DCSA#1 disengaged during Deploy or Retrieve mode with Staging Tube at equalized Seapressure ambient.
(5). DCSA#1 engaged (clamped) to permit Staging Tube Vent/Fill cycle for Antenna Element pressure equilization.
(6). CGA may be disengaged when B.C.A. scope deployed >624 feet at Ship speed >15 knots, or scope/speed combinations sufficient to generate >200#s
(7) SV/FV operation interlocked with AEPS, DCSA, and APSID sense. to ensure leaktight integrity during the Vent/Fill sequence.
(8) - HASR - Hyd. engage, Spring release
- SAHR - Spring engage, Hyd. release
- SVHF - Spring vent, Hyd. fill
- HSSR - Hyd. Shear, Spring release
(9) Valve, Seal position sensors not shown, would be for Control/Status interlock(s)

Figure 3.3.2.2.4. Staging Tube Configuration with Valves, Seals, C.G.A.s, and Sensors

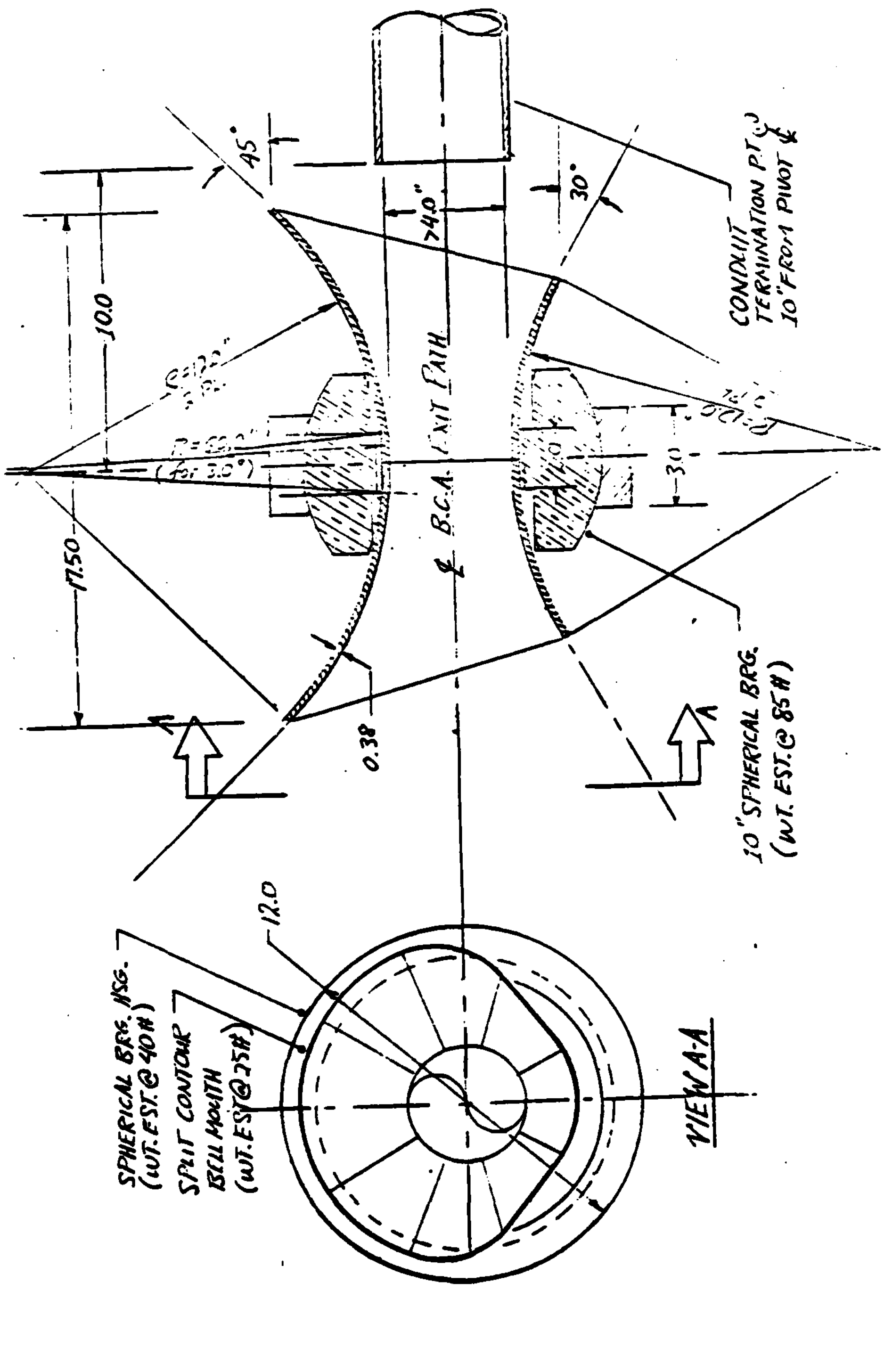


Figure 3.3.2.2.5. Articulated Bellmouth, Tow/Exit Point

Time, Sec.	DEPLOYMENT
	Sense Antenna Element @'A' w/AEPS #2
12.0 $\pm$ 3.0	Stop
(49.0)[1]	Vent Staging Tube (DCSA #1 activated)
(3.0)[1]	Open DCSA #2
28.5 $\pm$ 3.0	Start and Continue Deployment Increment Scope by T.B.D. Feet @ 1/10th Speed
1.5	Stop
3.0	Close DCSA #2
49.0	Fill Staging Tube, Equalize Antenna Element @ Ambient Seapressure
3.0	Open DCSA #1
12.0 $\pm$ 3.0	Start and Continue Deployment @200 → 400 FPM
109.0$\pm$9.0	

Time, Sec.	RETRIEVAL
	Interlock Cable Scope Count @T.B.D. Feet, reduce to 1/10th Speed
12.0 $\pm$ 3.0	Sense Antenna Element @'B' w/AEPS #1
	Stop
28.5 $\pm$ 3.0	Start and Continue Retrieval. Decrement Scope by T.B.D. Feet @ 1/10th Speed
1.5	Stop
3.0	Close DCSA #1
49.0	Vent Staging Tube, Equalize to Ambient Atmosphere
3.0	Open DCSA #2
12.0 $\pm$ 3.0	Start and Continue Retrieval @200 → 400 FPM
109.0$\pm$9.0	

NOTES:

(1) (49.0) and (3.0) are not included if DCSA #1 employed prior to Antenna Element sense at 'A'. A 2nd Antenna Element would require these two steps.

(2) The Staging Tube Vent/Fill time of 49.0 seconds is based upon the following: 7.5 ft. long annulus, 5.0 in. I.D. w/4 in. O.D. Antenna Element 4.0 ft. long; Estimated Displacement Volume required equals < 4.5 Gallons; the Vent/Fill line bore of 3.0 in., with seawater velocity ≤ 3.0 FPS provides rate of .092 GPS; 4.5 Gallons/.092 GPS = 49.0 seconds.

Figure 3.3.2.3.1. Antenna Element Passage through Staging Tube Configuration

DEPLOYMENT

Time, Sec.	
4.5	Power up, Disengage Pawl & Start Deployment @1/10th Speed
	Sense Cable End Termination @'A' w/AEPS #2
1.5	Stop
3.0	Open FSV #2
	Start @1/10th Speed
28.5 ± 3.0	Passage of Cable End Termination through DSA #2 Staging Tube & DSA #1
	Sense Cable End Termination @'B' w/AEPS #1, Activate DSCA #1
1.5	Stop
(49.0)[1]	Fill Staging Tube, Equalize @Ambient Seapressure
3.0	Open FSV #1 & HV
12.0 ± 3.0	Start & Deploy @200 → 400 FPM until Desired Scope
54.0 ± 6.0	

RETRIEVAL

Time, Sec.	
	Power up, Disengage Pawl, MSSV & Start Retrieval @200 → 400 FPM
	Interlock Cable Scope Count @T.B.D. Feet, reduce to 1/10th Speed
12.0 ± 3	
	Sense Cable End Termination @'B' w/AEPS #1
1.5	Stop
3.0	Close HV & FSV #1
(49.0)[1]	Vent Staging Tube, Equalize to Ambient Atmosphere
	Start @ 1/10th Speed
28.5 ± 3.0	Passage of Cable End Termination through DCSA #1 Staging Tube and DCSA #2
1.5	Sense Cable End Termination @4' w/AEPS #2. Stop.
3.0	Close FSV #2, Deactivate DCSA #1
	Continue Retrieval @1/10th Speed until Scope equals 0
4.5	Stop, Engage Pawl & Power Down
54.0 ± 6.0	

NOTES:

(1) The (49.0)* seconds is not included in the total passage time if DSCA #1 is employed as the operational dynamic seal.

(2) Optimization of the sequence and representative times must be made through further Detailed Definition. The above operational modes are representative only!

Figure 3.3.2.3.2. Cable End Termination Passage through Staging Tube Configuration

3.3.2.4.2 Performance

PROs

- Capable of handling large diameter Antenna Elements w/o high column loading forces being generated on the buoyant cable

CONs

- Antenna Element size dictates Config./Interface requirements
- *Intermittant cycle interrupt* required to sequence the Antenna Element through the Staging Tube Assembly
- Conduit I.D. vs. Buoyant Cable O.D. creates potentially serious deployment difficulties re--"buckling".

Concept B is not responsive to SOW Requirement #19, being approximately 22% heavier than required. This is a minor system deficiency in this DRSS concept.

3.3.3 Concept C

3.3.3.1 General Description

- For handling any cable diameter or 4.0, 6.0 Antenna Elements. Does not require dynamic seals. Very simple.
- Few problems and risk areas associated with this concept - except for major installation impact with respect to pressure hull modification, weight and envelope requirements (see Figure 3.3.3.1).

3.3.3.2 Detail Definition

The system functional interrelationships are shown in Figure 3.3.3.2.1, with a detail component breakdown provided in Figure 3.3.3.2.2. The components/subsystems have been selected from tradeoff analyses made during the component level studies presented in Volume II.

3.3.3.3 System Operation

Referring to Figure 3.3.3.1, with the Pressure Proof Hatch (11) closed, the Hull Shut-off Valve (4) is opened to the full bore of the conduit which can be 6.0 inches. The Fail Safe Valve (6) is then cracked to allow seawater to flood the Trunk (7). The Transfer Mechanism (8) is then used to push the cable/antenna assembly through the fail safe valve into the Conduit (3). To accomplish this unattended, the end of the cable/antenna element must have been prethreaded through the transfer mechanism and started into the inboard end of the conduit.

On retrieval, the transfer mechanism retrieves the cable/antenna assembly into the flooded trunk until the Cable/Antenna Element Proximity Sensor (2) automatically stops the retrieval with the cable/antenna assembly resting in the conduit such that the end is at the Tow Point (1). The DRSS system is stored this way until it is needed for deployment again.

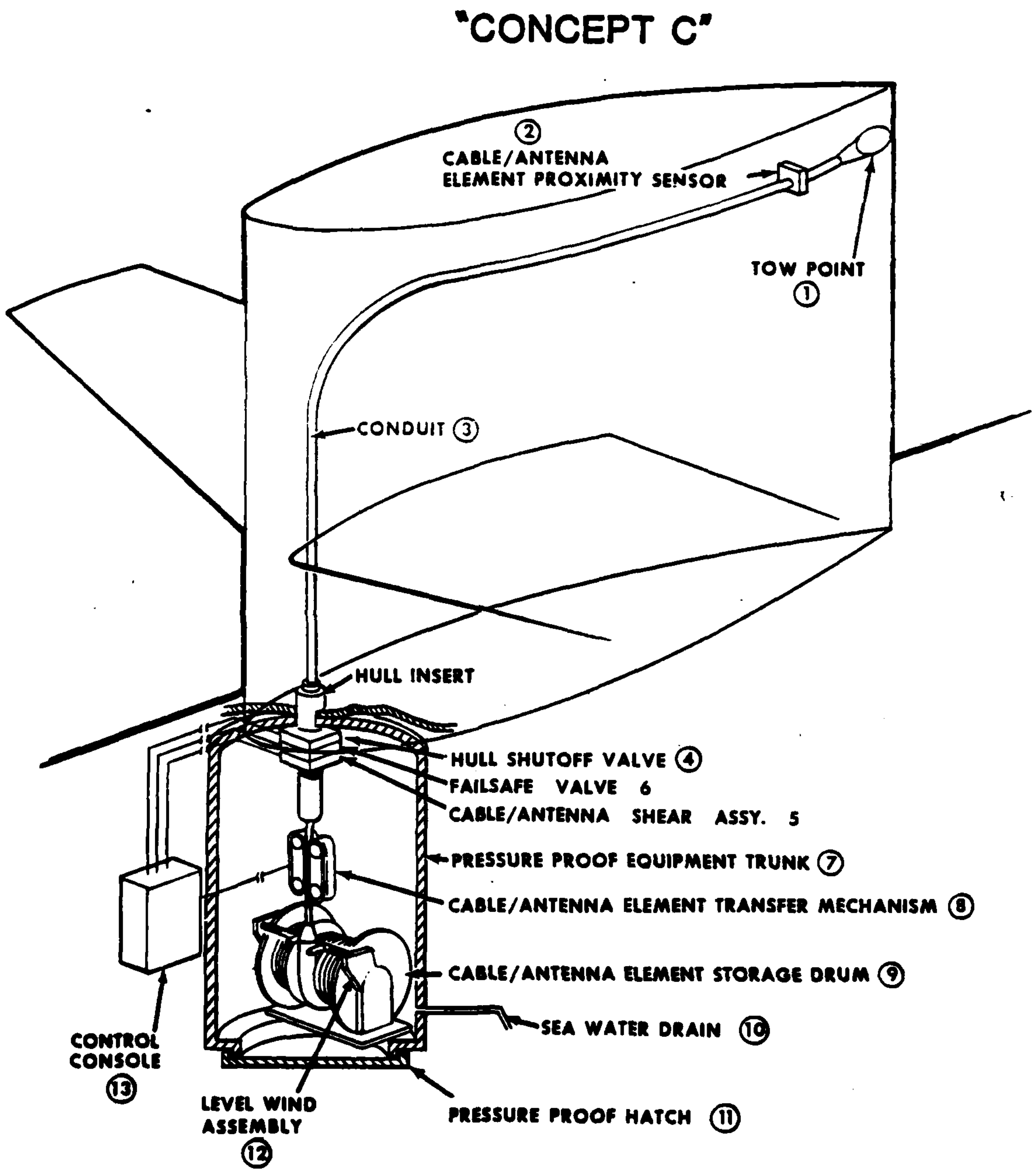


Figure 3.3.3.1. System Concept C

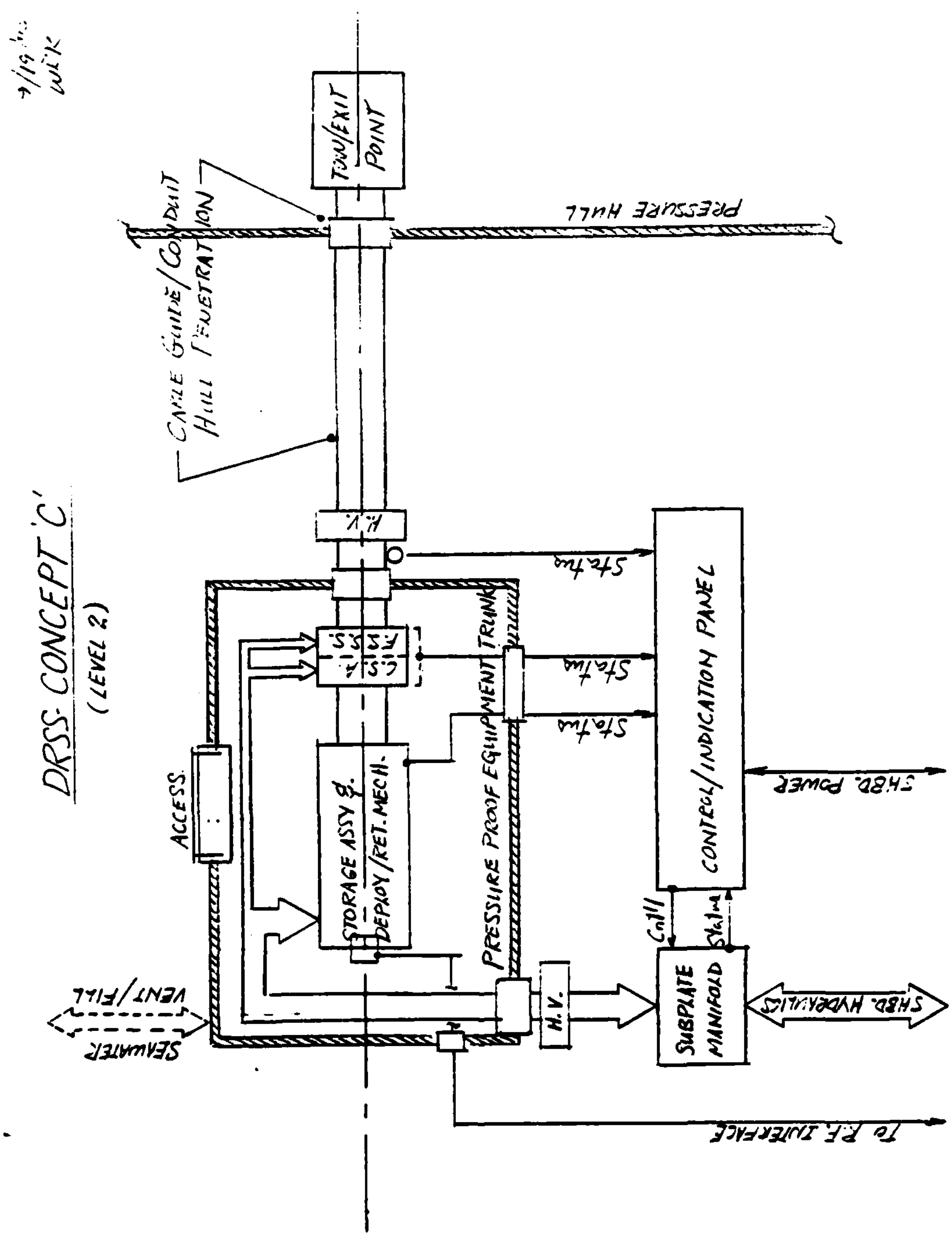


Figure 3.3.3.2.1. Concept C Functional Interrelationship

Component/Subsystem	Vol, FT^3	Wt. #
• Dep. Ret. Mechanism - Single Drum Capstan	25.21*	2300
(use Aluminum const.)	less	760
• Storage Assembly - CHETSA Concept	42.85*	1887
(use Aluminum const.)	less	987
• Failsafe Shutoff Valve (6" Ball Valve)	.50	100
• Cable/Antenna Element Shear Assembly (similar to BRA-24)	.50	100
• Hull Shutoff Valve (6" Ball Valve)	.50	100
• Antenna Element Proximity Sensor (similar to CHETSA)	.06	1.2
• Cable Scope Sensor (2 ea)	.125*	2.5
• Seal/Valve Position Sensor (3 ea) (Limit Switch Configuration)	.12	2.3
• Conduit-Guide Tube 4.38 ID x 30' Lg.	3.90	393
- (plus Outboard Sheave 48 in. OD x 5" wide)	5.23	350
- (plus Seawater Vent/Fill Valve)	.50	100
- (plus Pressure, Vessel, less (*))	86.60	6800
• Tow/Exit Point, 4.38 Bellmouth Bore	.84	150
	98.88	10,539.0

Operational/Performance Capability Summary

- .65 → 4.0 dia. Buoyant Cable Assembly
- $4125\#_f$ Dynamic Load
- 5000 ft Cable Storage
- W/2-Speed Opn'l Mode >20 knots @200 FPM, 5000 ft scope & >20 knots @400 FPM, 2500 ft scope
- MTBF ≥976 Hrs; Deploy/Retrieve Cycle Time equals 16.7 minutes w/7 ea. 4.0 in. Dia. x 4 ft Long Antenna Elements

Figure 3.3.3.2.2. Concept C Detail Definition Summary

3.3.3.4 Conclusion

3.3.3.4.1 Risk Areas

(a) Pressure Proof Access Trunk

(b) Combination Transfer Mech/Storage Assembly such that size of the Trunk is minimized.

3.3.3.4.2 Performance

PROs	CONs
• Modular Package	• Potential impact on installation modification to the submarine and internal components is extremely severe
• No dynamic seal requirement	• Envelope & Wt. Spec. Reqts would be exceeded.
• Potentially high reliability	• A method must be developed to effect re-insertion of B.C. Assy end termination after maintenance is completed on the B.C.A. A Manual or Auto. Static Seal is also essential.

Concept C is not responsive to SOW Requirement #7, and #19, and would also violate by almost a factor of two - the unit cost of $175,000. Major ship alterations would be necessitated at factors from two to ten that of the Installation Cost of $200,000. These last two items constitute major system deficiencies.

3.3.4 Concept D

3.3.4.1 General Description

- Can handle only moderate diameter (.50 → 1.00 inch) cables and Antenna Elements.
- 'lust flood the Main Access Trunk - the question of SUBSAFE integrity being maintained is doubtful.
- Imposes unique component configuration limitations in order to fit within the available space (see Figure 3.3.4.1).

3.3.4.2 Detail Definition

The system functional interrelationships are shown in Figure 3.3.4.2.1, with a detail component breakdown provided in Figure 3.3.4.2.2. The components/subsystems have been selected from tradeoff analyses made during the component level studies presented in Volume II.

3.3.4.3 System Operation

Referring to Figure 3.3.4.1 with the Lower Main Access Hatch closed, the upper Main Access Hatch is opened. Seawater floods the Trunk. The Transfer Mechanism is then used to push the cable/antenna assembly through the fail safe valve into the Conduit. To accomplish this unattended, the end of the cable/antenna element must have been prethreaded through the transfer mechanism and started into the inboard end of the conduit.

On retrieval, the transfer mechanism retrieves the cable/antenna assembly into the flooded trunk until the Cable/Antenna Element Proximity Sensor automatically stops the retrieval with the cable/antenna assembly resting in the conduit such that the end is at the Tow Point. The DRSS system is stored this way until it is needed for deployment again.

As Subsafe conditions would appear to be violated by the above scenario, Figure 3.3.4.2.1 was configured to make it similar to system Concept C, yet take advantage of an

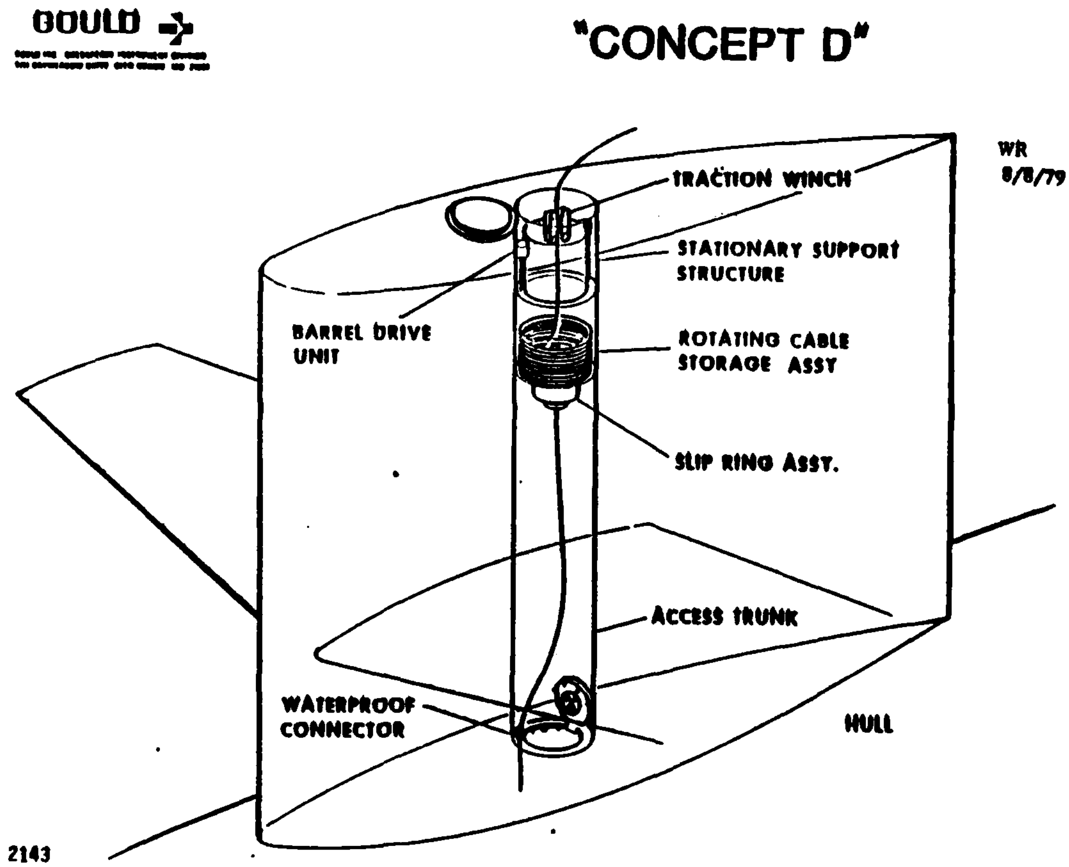


Figure 3.3.4.1. System Concept D

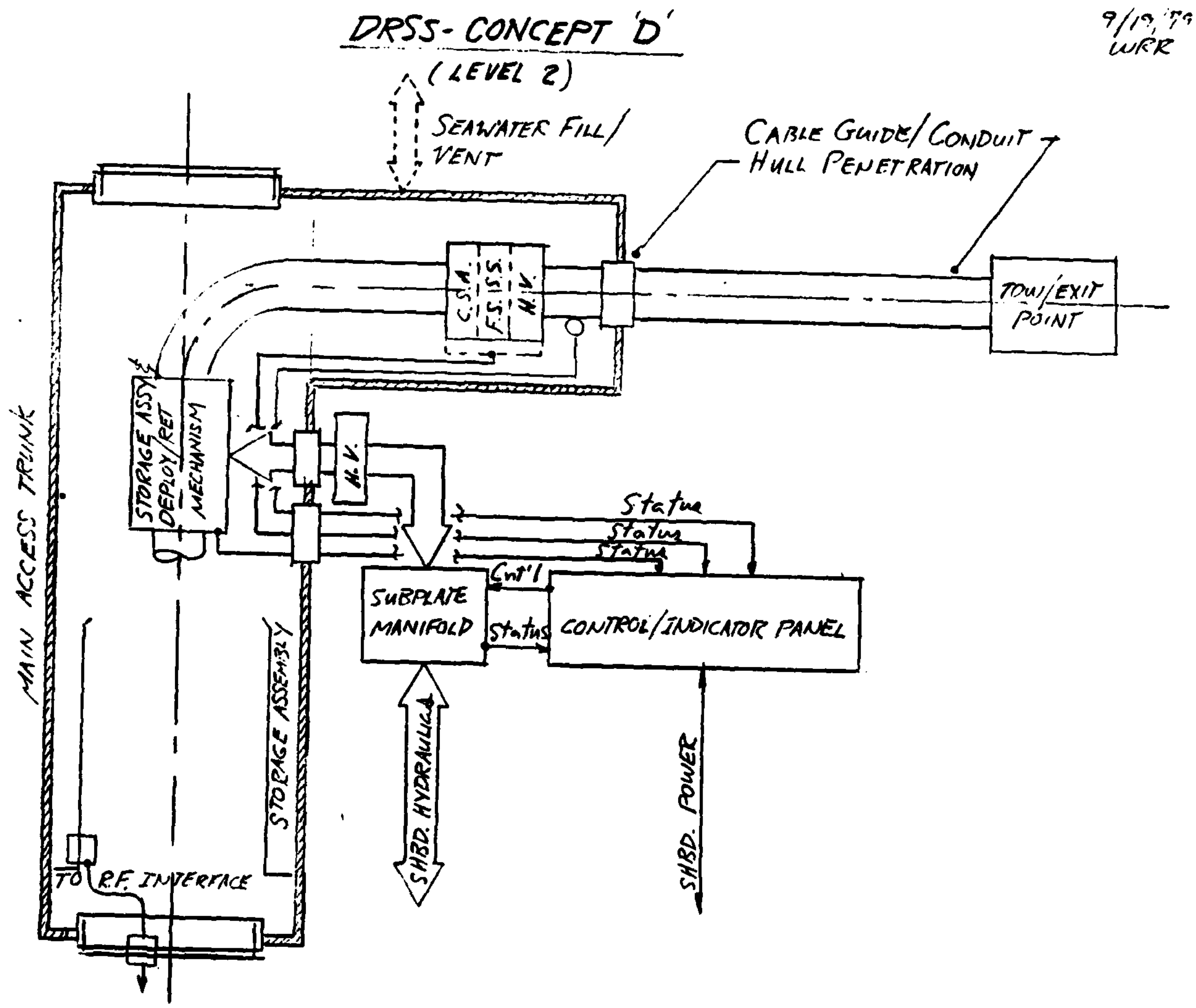


Figure 3.3.4.2.1. Concept D Functional Interrelationship

Component/Subsystem

Identical to System Concept C Configuration, except that the Main Access Trunk (MAT) is employed as the Pressure Vessel. Assuming that the MAT is 20 ft long x 26 in. ID equals a maximum available volume for the DRSS equal to 73.70 FT^3. An 18 in. Pitch Diameter Single Drum Capstan would be the only feasible Dep./Ret. Mechanism for this application, and a Storage Assembly - Barrel Stuffing Concept the only feasible means to store the cable. The weight is indeterminate at this time due to the severe packaging problems associated with this concept. A maximum estimated weight would be 3175#.

Operational/Performance Capability Summary

- .65 → 1.38 dia. Buoyant Cable Assembly
- 11,000$\#_f$ Dynamic Load
- 5000 ft Cable Storage
- W/2-Speed Opn'l Mode >20 knots @200 FPM, 5000 ft scope
& >20 knots @400 FPM, 2500 ft scope
- MTBF ≥ 216 Hrs; Deploy/Retrieve Cycle Time equals 16.7 minutes w/7 ea. 1.38 in. Dia. x 1.38 ft Long Antenna Elements

Figure 3.3.4.2.2. Concept D Detail Definition Summary

existing Pressure Proof Access Trunk. Configured in this manner, the operation would be identical to that described in paragraph 3.3.3.3.

3.3.4.4 Conclusion

3.3.4.4.1 Risk Areas

(a) Combination Transfer Mech/Storage Assembly such that size of the encapsulated configuration is minimized and that the Diameter be $<$26.0 in.

(b) That the integral Tow/Exit Point out the top Hatch permit free-streaming of the B.C.A. w/o interference; or separate Outlet required.

(c) That the top hatch be automatically open and closed; or separate Outlet required.

3.3.4.4.2 Performance

PROs	CONs
• Minimizes impact on installation/ modif. to the submarine and internal components.	• Extremely difficult packaging/ interface problems for DRSS component integration. • Tight bend radii imposed. • Antenna Element Storage problems magnified. • Transfer Mech. Config. reqts are extremely limited -- driving packaging/interface reqts. A dynamic Seal with Staging tube would be required if Top Hatch and/or, flooding of the Main Access Trunk is not permitted.

Concept D is not responsive to SOW Requirement #11, permitting only a 1.38 in. vs 4 in. diameter B.C.A. capability. This is a major system deficiency.

3.3.5 Concept E

3.3.5.1 General Description

For handling large diameter (4.0, 6.0 inch) Antenna Elements with either .50, 1.00 inch or .65 inch buoyant cable.

- Provides for installation in the Aft Main Ballast Tank similar to CHETSA, reducing impact of "premium" envelope requirements/installation impact within the pressure hull (see Figure 3.3.5.1).
- Does not require operational dynamic seals or a staging tube. The buoyant cable assembly is diverted through the pressure hull whenever maintenance of the buoyant cable assembly is required.
- Component reliability for the Transfer Mechanism/and Cable/Antenna Elements Storage Assembly must be equivalent to that achieved for CHETSA -- as these items are non-maintainable for the mission duration. The Divertor Valve Assembly is a key component, in order to provide means to effect cable maintenance.

3.3.5.2 Detail Definition

The system functional interrelationships are shown in Figure 3.3.5.2.1, with a detail component breakdown provided in Figure 3.3.5.2.2. The components/subsystems have been selected from tradeoff analyses made during the component level studies presented in Volume II.

3.3.5.3. System Operation

Deploy Operation

A. Hull Valve and fail safe shutoff valves are closed.

B. The deploy/retrieve mechanism is activated at slow speed and gradually opens to accommodate the large diameter antenna element. The drag load on the antenna assembly assists in the payout through the conduit/guide tube.

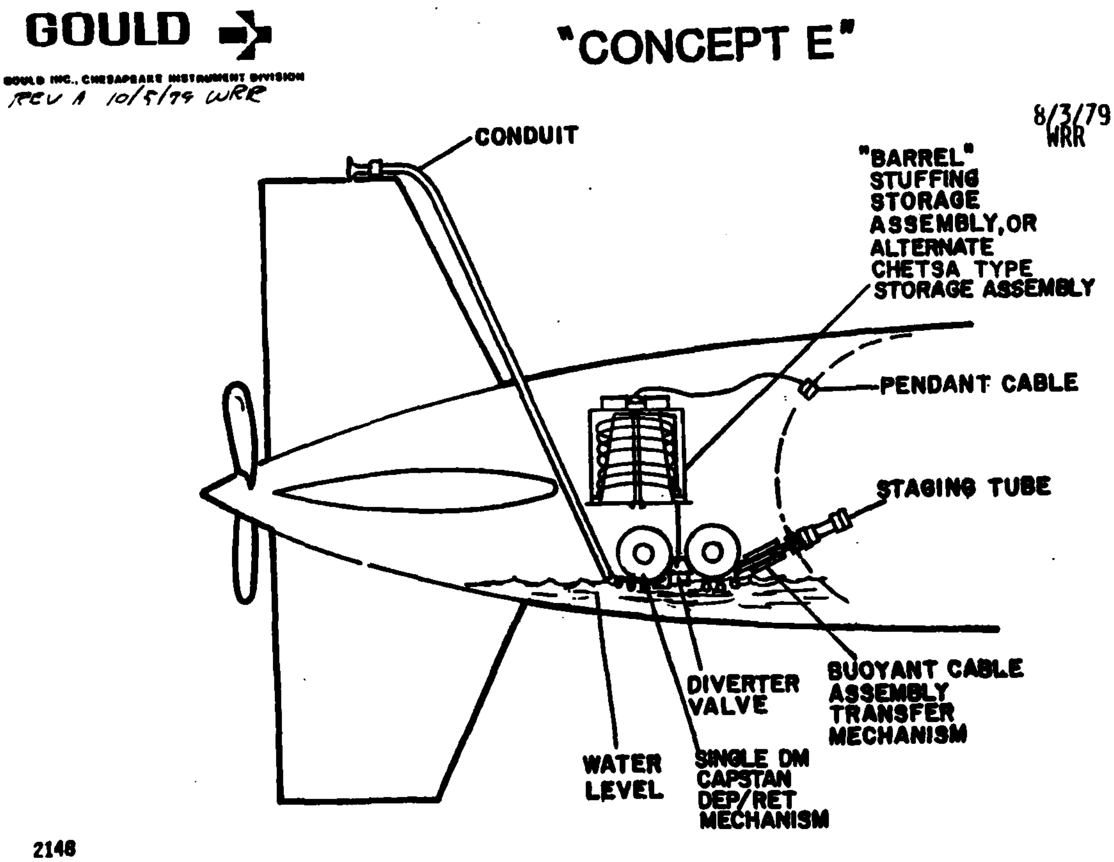


Figure 3.3.5.1. System Concept E

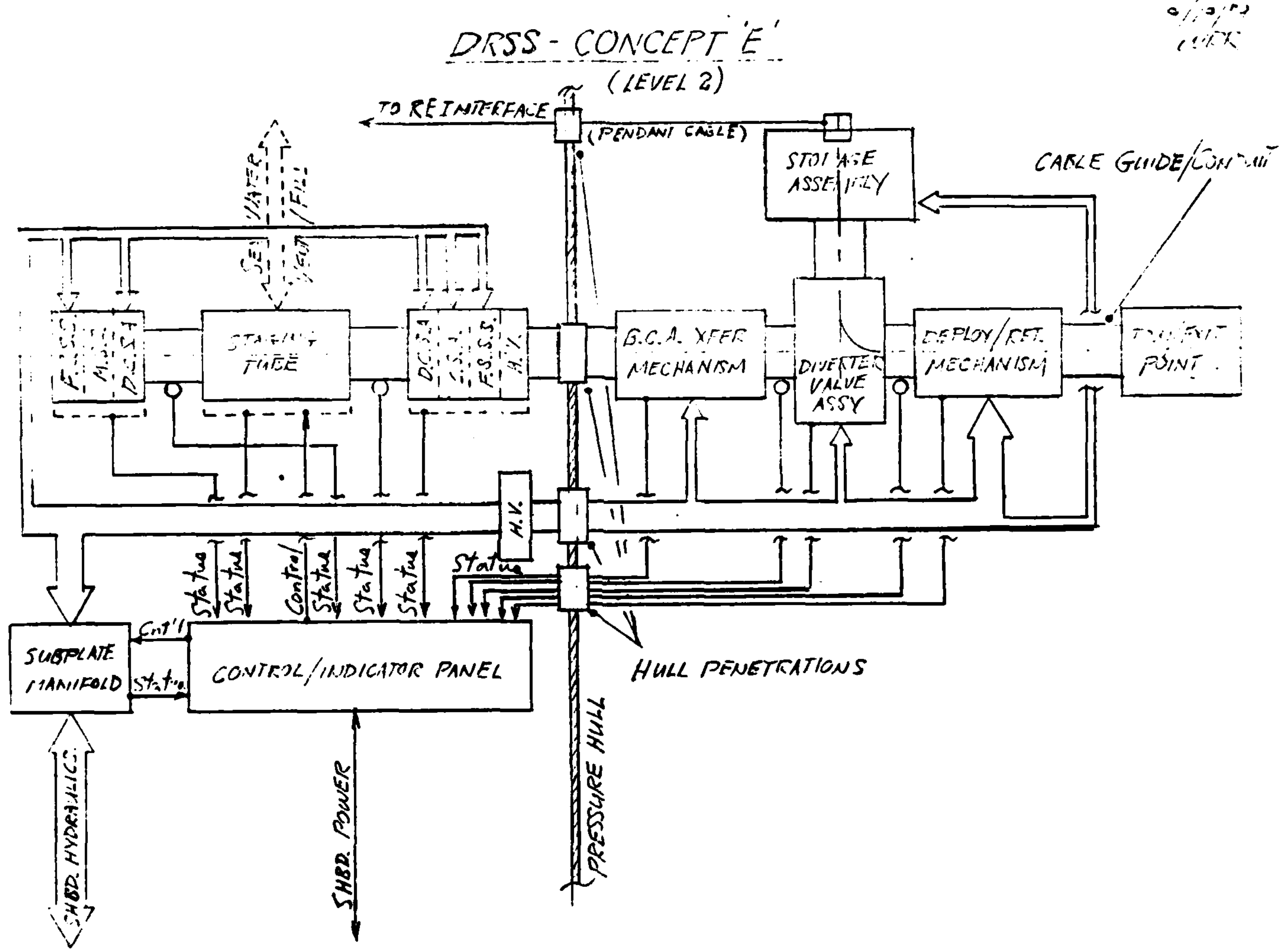


Figure 3.3.5.2.1. Concept B Functional Interrelationship

Component/Subsystem

Identical to System Concept B Configuration, except that the location would in the Aft. Main Ballast Tank. It is estimated that an additional 15 ft of 4.38 ID Conduit would be required @2 FT^3 and < 200#, a Transfer Mechanism Stage @6.86 FT^3 and 318#, a Divertor Valve Assembly estimated at < 4.0 FT^3 and < 200#, and elimination of the Outboard Sheave @5.23 FT^3 and 250#. The net adjustment is +7.63 FT^3 and +368#, for an adjusted total of 90.24 FT^3 and 4625.0#.

Operational/Performance Capability

- .65 → 4.0 dia. Buoyant Cable Assembly
- $4125\#_f$ Dynamic Load
- 5000 ft Cable Storage
- W/2-Speed Opn'l Mode - 17.0 knots @200 FPM, 5000 ft scope (@60° Bend = 1.52X) & 17.0 knots @400 FPM, 2500 scope
- MTBF ≥ 1600 Hrs; Deploy/Retrieve Cycle Time equals 16.7 minutes w/7 ea. 4.0 in. dia. x 4 ft long Antenna Elements.

Figure 3.3.5.2.2. Concept E Detail Definition Summary

C. A proximity sensor indicates position of the antenna element and cable is consequently deployed at fast speed until an additional antenna element attachment point is reached.

D. When deployment is complete, the pawl is engaged for long term towing with the cable/antenna element assembly trailing. The cable is tensioned against the deploy/retrieve mechanism, to take the entire 6000 to 10,000 lb. tension load during towing.

Retrieval Operation

The retrieval operation is the reverse of the deployment operation except that Cable/Antenna Element Proximity Sensor (2) senses the approach of an antenna element and slows down the Deploy/Retrieve Transfer Mechanism, while the antenna element is passing through the Conduit/Guide Tube.

Maintenance Operation

This maintenance system concept works by using the Antenna Element Staging Tube, item (9) in Figure 3.3.5.2.1 as a sea chest. With the upper valves and seals closed, the lower seals are opened to a full 6 inch diameter bore. The transfer mechanism pushes the antenna element into the tube, the lower seals are then closed and the upper seals opened to the full 6 inch diameter bore. The antenna element is then injected through the pressure hull.

3.3.5.4 Conclusion

3.3.5.4.1 Risk Areas

(a) Divertor Valve Assembly for injection of the B.C.A. end termination into a staging tube assembly.

3.3.5.4.2 Performance

PROs	CONs
• Modular Package	• Not responsive to Spec
• No dynamic seals	• Very high reliability required
• "Zero" envelope reqts on installation space within the pressure hull.	• Divertor Valve Assy must be developed.
• Guide Tube Angle reduce by approx. 30°	• ≈ 28 ft. running depth loss due to relocation of Tow/Exit Point.

Concept E is not responsive to SOW Requirements #8 and #19. Failure to meet SOW Requirement #8 is potentially a major system deficiency, because the concept requires very high system reliability due to its inaccessibility.

SECTION 4

SECTION 4

TRADEOFF ANALYSIS

4.1 METHODOLOGY

4.1.1 Requirements Analysis

From the RFP and associated data furnished with the RFP, the purpose of the buoyant cable antenna is clearly defined as allowing the submarine to communicate with the outside world while remaining at submergence depths. The antenna is used to receive EM energy in the ELF to UHF bands along with Loran data. Since this bandwidth is very large, the attenuation characteristics of the antenna and cable are very important, especially since the SOW requires that the length of the antenna be extended to a minimum of 3000 feet with a goal of 5000 feet. To achieve the required EM signal level at the inboard end of the cable, amplification and equalization networks are required.

The antenna designer is thus faced with the problem of packaging these networks in the small diameter envelope of the cable with the additional requirement of obtaining the mechanical characteristics required to survive the transfer mechanism and seals. It is therefore desirable that the antenna elements be allowed to grow in diameter to allow the designer more capability to achieve enhanced antenna performance. An additional benefit of the large diameter antenna elements is the increased positive buoyancy that might result.

The physical and hydrodynamic characteristics of the cable/antenna are important because they directly affect the depth at which the submarine can tow the antenna at any given submarine speed. The ideal set of antenna/cable physical and hydrodynamic characteristics would allow the antenna to reach the surface while the submarine was operating at high speed and great depth. The antenna designer must work toward these ideal conditions by providing maximum positive buoyancy to achieve lift, minimum diameter to reduce hydrodynamic drag and down force, and maximum cable length. The DRSS designer must then provide handling equipment which can exert the required static

and dynamic forces without damaging the cable/antenna. He must also provide capability to store the maximum length of antenna/cable system. It is also very important that the DRSS deployment/retrieval line speed be considered an important design factor.

Subsafe Requirements must be addressed. Both a Hull Valve and an automatic Failsafe Shutoff Valve must be developed to provide for pressure hull integrity when the Buoyant Cable Assembly is fully retrieved, accidentally lost or intentionally sheared.

The Buoyant Cable Antenna System (BCA) physical configuration and characteristics must be further defined in order to resolve final interface requirements upon the DRSS handling system, as defined by the baseline system concept recommended by the study effort.

After studying the 688 and 637 class submarines to address the desire to backfit DRSS into these ships, it was clear that installation feasibility and cost will be a major driver of the DRSS. Because of the $200,000 desired installation cost, massive modifications to the submarine pressure hull, external hydrodynamic lines or internal spaces are not considered feasible even though this approach might yield a simple high performance DRSS system.

Thus, the System Level Design Drivers which lead to the evaluation of DRSS System Concepts are:

a) Antenna Mission Requirements

b) Desired Antenna Characteristics

c) Submarine Backfit and Installation Considerations

These design drivers are reflected in the following key system level requirements and goals.

1.	Antenna Element Diameter	4.0 to 6.0 inches
2.	Antenna/Cable Length	3000 to 5000 feet
3.	Deployment Retrieval Time	Minimized (200 fpm to 400 fpm)
4.	Dynamic Load Capability	3000 → 6000 pounds
5.	Installation Cost	$200,000

6. Weight < 3500 pounds

7. Volume < 85 FT^3

4.1.2 Analytical Approach

A conceptual system design has been defined through tradeoffs of component characteristics within each system concept and then tradeoffs between the optimized system concepts proposed.

Our procedure for achieving these tradeoffs entailed first refining the proposed system concepts with the Program Sponsor so that we could bring as much realism to the study program as possible. Second, we implemented component studies, conceptual designs and tradeoffs to enable us to characterize the necessary components. Thirdly, we used the component characteristics to define the performance of the proposed systems and then implemented system level tradeoffs.

Each of these steps has been closely coordinated through Program Review Meetings so that the study could take advantage of available expertise and direct the effort to achieve practical results.

The following procedure applies to all Tradeoff Analysis performed for the DRSS study effort.

- Establish a number of fundamentally different Configuration Concept(s) for each DRSS study area required by the SOW.
- Establish Evaluation Criteria which consist of all allocated SOW Requirements and Goals, and additional evaluation criteria as selected by CID.
- Generate numerical values as determined by analysis, for assessment of each of the Evaluation Criteria selected.
- Normalize all numerical values and apply a weighting factor as follows:
  - CID Evaluation Criteria @ 1X
  - SOW Requirement @ 2X
  - SOW Goals @ 3X

- Installation Impact Factor @ 3X
- Per Unit Cost Factor @ 3X

NOTE

The last three items are necessary to implement the SOW System Tradeoff Priorities described in Paragraph 2.1.

- Summarize the normalized and weighted values for each concept evaluated, and select that concept with the highest overall statistically significant value.

4.2 TRADEOFF MATRIX

The first chart, Figure 4.2.1 depicts the values derived in the Evaluation Criteria Analysis, Appendix A. The second chart, Figure 4.2.2 depicts the final numerical summary, with values generated as follows:

(a) Select the optimum value in each of the successive columns

(b) Normalize all other values in that column against the optimum value.

(c) Apply the appropriate factor, i.e., CID evaluation criteria @ Base; Requirement @ 2X Base; and Goal at 3X Base.

(d) Sum the horizontal rows to generate the intermediate subtotal and the final grand total.

From the Tradeoff Matrix, the following statistical evaluation was made to rank the candidate concepts.

(a) Mean Value = 58.27; Standard Deviation = .856

(b) Ranking based upon highest value and with significant difference defined as greater than one standard deviation from the maximum ranking values:

System Concept A - 1st @ 59.24

System Concept B - 1st @ 58.57

System Concept E - 1st @ 58.55

REQUIREMENTS	A	B	C	D	E
Reqt. #1	6	9	3	9	2
Reqt. #2	X	X	X	X	X
Reqt. #3	X	X	X	X	X
Reqt. #4	X	X	X	X	X
Reqt. #5	1	1	1	3	1
Reqt. #6	X	X	X	X	X
Reqt. #7	74.3	82.6	98.9	73.7	90.24
Reqt. #8	X	X	X	X	-
Reqt. #9	X	X	X	X	X
Reqt. #10	X	X	X	X	X
Reqt. #11	1	4	4	1.38	4
Reqt. #12	5000	5000	5000	5000	5000
Reqt. #13	X	X	X	X	X
Reqt. #14	X	X	X	X	X
Reqt. #15	X	X	X	X	X
Reqt. #16	X	X	X	X	X
Reqt. #17	X	X	X	X	X
Reqt. #18	X	X	X	X	X
Reqt. #19	3175	4257	10539	3175	4625
Reqt. #20	X	X	X	X	X
GOALS					
Goal #1	X	X	X	X	X
Goal #2	X	X	X	X	X
Goal #3	X	X	X	X	X
Goal #4	X	X	X	-	X
Goal #5	X	X	X	X	X
SUBTOTAL					
CID EVALUATION CRITERIA					
Performance Reqt. Achievement Factor	3	3	2	1	3
Reliability Factor, MTBF	645	432	976	216	1600
Design Goal Achievement Factor	2.4	2.4	2.4	2.2	2.2
Interface Reqts. Factor	12	17	11	17	8
Installation Impact Re. Vol, Wt. Factor	3	2	1	1	2
Unit Cost Based Max No. Des. Goals Factor	140K ±15%	172K ±5%	300K ±25%	172K ±15%	215K ±15%
GRAND TOTAL					

Figure 4.2.1

REQUIREMENTS	A	B	C	D	E
Reqt. #1	.67	.44	1.33	.44	2
Reqt. #2	2	2	2	2	2
Reqt. #3	2	2	2	2	2
Reqt. #4	2	2	2	2	2
Reqt. #5	2	2	2	2	2
Reqt. #6	2	2	2	2	2
Reqt. #7	2	1.80	1.50	-	1.65
Reqt. #8	2	2	2	2	-
Reqt. #9	2	2	2	2	2
Reqt. #10	2	2	2	2	2
Reqt. #11	.50	2	2	.69	2
Reqt. #12	2	2	2	2	2
Reqt. #13	2	2	2	2	2
Reqt. #14	2	2	2	2	2
Reqt. #15	2	2	2	2	2
Reqt. #16	2	2	2	2	2
Reqt. #17	2	2	2	2	2
Reqt. #18	2	2	2	2	2
Reqt. #19	2	1.49	.60	-	1.37
Reqt. #20	2	2	2	2	2
GOALS					
Goal #1	3	3	3	3	3
Goal #2	3	3	3	3	3
Goal #3	3	3	3	3	3
Goal #4	3	3	3	-	3
Goal #5	3	3	3	3	3
SUBTOTAL	52.17	52.57	52.58	47.76	51.96
CID EVALUATION CRITERIA					
Performance Reqt. Achievement Factor	1	1	.66	.33	1
Reliability Factor, MTBF	.41	.27	.61	.14	1
Design Goal Achievement Factor	1	1	1	.92	.92
Interface Reqts. Factor	.66	.47	.73	.47	1
Installation Impact Re. Vol, Wt. Factor	1	.66	.33	.33	.66
Unit Cost Based Max N° Des. Goals Factor	3	2.94	1.40	2.44	1.95
GRAND TOTAL	59.24	58.57	57.46	52.39	58.55

Figure 4.2.2

System Concept C - 2nd @ 57.16

System Concept D - 3rd @ 52.39

This ranking shows a statistical tie for the best concept among Concepts A, B and E. This is discussed in the next paragraph.

4.3 DISCUSSION OF THE TRADEOFF MATRIX AND CONCLUSIONS

As noted in the previous paragraph, a statistical tie exists for the best system. There are two primary reasons for this result. The first is that since these were concepts and not final designs which were evaluated, the evaluation criteria were quite coarse in their ability to discriminate one system from another. The second is that CID made the decision to leave all concepts in the evaluation, even though several of them violated requirements. This allows the government to determine if the benefit of one of these systems might outweigh the impact of the violated requirement.

Overall, the system tradeoff employing the 31 evaluation criteria has shown that Concepts A, B and E are significantly better at meeting the requirements and achieving the goals than are concepts C and D. Additionally, the tradeoff has defined the subjective conclusion that Concept B is the best system to meet all requirements and achieve the goals. This conclusion is based upon the following rationale:

(a) Concept A is not responsive to SOW Requirement #11. This is a major system deficiency in a DRSS concept, permitting only a maximum diameter of 1 in. vs the 4 in. required.

(b) Concept B is not responsive to SOW Requirement #19, being approximately 22% heavier than required. This is a minor system deficiency in this DRSS concept.

(c) Concept C is not responsive to SOW Requirements #7, and #19, and would also violate by almost a factor of two - the unit cost of $175,000. Major ship alterations would be necessitated at factors from two to ten that of the Installation Cost of $200,000. These last two items constitute major system deficiencies.

(d) Concept D is not responsive to SOW Requirement #11, permitting only a 1.38 in. vs 4 in. diameter B.C.A. capability. This is a major system deficiency. Additionally, extremely high density packaging requirements imposed by its location entail very high engineering development risk.

(e) Concept E is not responsive to SOW Requirements #8 and #19. Failure to meet SOW Requirement #8 is potentially a major system deficiency, because the concept requires very high system reliability due to its inaccessibility. It should be noted however, that the CHETSA system for the TBE towed array is located in a similar location, and that with few configuration adjustments is virtually identical in its functional characteristics. The CHETSA system MTBF is in the vicinity of 20,000 Hrs, with properly scheduled maintenance. Note that Concept E provides means to maintain the buoyant cable assembly.

SECTION 5

SECTION 5

CONCLUSIONS

The five concepts, and in turn, the many components which comprise these concepts had to meet specified requirements and achieve goals as well as meet unit and installation cost. The tradeoffs demonstrate that installation cost is the major system driver. Major modification of current submarine designs allows the installation of the simplest, most capable and least risky DRSS.

This system, identified as Concept C, places the DRSS in a pressure proof access trunk designed and sized specifically for the system. Although Concept C has the advantages of simple design and low risk, the installation of the pressure proof access trunk requires reconfiguration of the submarine internal arrangement and equipment. Preliminary cost estimates show that this kind of alteration exceeds by an order of magnitude the $200K installation cost goal. The study concludes that Concept C is not acceptable for this reason.

Concept E, which places the DRSS in an aft ballast tank, also provides a low risk means of deploying and retrieving the large diameter antenna elements. However, the concept violates the requirement to have access to the deploy/retrieve mechanism and storage asembly for maintenance. The study concludes that Concept E must be downgraded, but could be acceptable with the implementation of a revised maintenance concept.

Concept D, which utilizes the current main access trunk to house the DRSS, causes either unacceptable antenna packaging or SUBSAFE problems. This caused a very severe downgrading of the concept in the tradeoffs.

Concept A was an attempt to define a system very similar to the current AN/BRA-24 which would achieve the deployment and retrieval of moderate diameter antenna elements. The component study on seals shows that the required dynamic seal

exceeds the state of the art and that there is little likelihood that materials technology will ever exist to meet this requirement.

The study shows that Concept B is the best concept. The concept implements a staging tube to eliminate the requirement for the pressure proof access trunk of Concept C. The staging tube also provides the capability to handle the 4 inch diameter antenna elements because the dynamic seal required for this concept can be developed. This is not to conclude that the components required for Concept B can be procured off the shelf. New valves and seals will have to be developed. The deploy/retrieve mechanism will have to be further defined. The conclusion is that a conceptual design exists which meets the requirements and can achieve most of the goals.

Because of the commonality of components among system concepts, CID recommends that further system definition be established only for Concept B. A reasonable spectrum of system options remains open because the high risk areas which must be further studies as part of Concept B are applicable to other concepts as well. This will allow the Navy extended participation and guidance in the concept definition and provide more clearly defined options upon which to base decisions for transition from concept feasibility to concept validation.

In the near term, we further recommended that detail definition and risk assessment be undertaken for the following areas identified as high risk for Concept B during this study.

1. Deploy/Retrieve Mechanism
    a. Motor
    b. Pinch Rollers
2. Staging Tube
    a. Cable Support Assemblies
    b. Seals
    c. Valves

APPENDIX A

AD-A084 004 GOULD INC GLEN BURNIE MD CHESAPEAKE INSTRUMENT DIV F/G 17/2.1
DEPLOY/RETRIEVE STORAGE SYSTEM (DRSS). VOLUME I. SYSTEM LEVEL D--ETC(U)
JAN 80 N00039-79-C-0329

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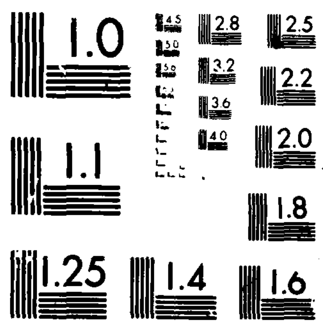

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX A

EVALUATION CRITERIA ANALYSIS

INTRODUCTION

The evaluation criteria analysis (ECA) provides a summary of the methodology employed in generating the numerical ratings presented in the tradeoff summary charts. The ECA includes the assumptions used in the analysis so that a better understanding of the assessment may be obtained.

Three kinds of evaluation criteria were used in the study. The first two are SOW requirements and goals. The third is the CID evaluation criteria. The CID evaluation criteria were employed because these additional engineering considerations were considered necessary by CID to help discriminate among the many candidates in each tradeoff analysis.

EVALUATION CRITERIA ANALYSIS

Requirement 1

- All concepts can meet the requirement for positive self sealing.
- Ranking is established based upon the number of values and seals inherent in each concept. The dynamic seals are weighted at 2X.

  Concept A - (6)

  W/HV, FSSV, MSV, DCSA @ 2X and CSA.

  Concept B - (9)

  W/HV, FSSV (2 ea reqd.), MSV, DCSA (2 ea. reqd.) @ 2X, and CSA

  Concept C - (3)

  W/HV, FSSV and CSA.

  Concept D - (9), Option 1 and 3, Option 2

  Option 1 would be identical to Concept B in order to achieve SUBSAFE conditions in the Main Access Trunk.

  Option 2 would be similar to Concept C (Pressure Proof Access Trunk); however, SUBSAFE conditions would be violated.

  Select Option 1 in order to achieve SUBSAFE conditions.

  Concept E - (2)

  W/HV and FSSV to achieve SUBSAFE conditions under operational conditions. Note that this concept locates the DRSS within the Aft Main Ballast Tank and the the B.C.A. is only brought inboard when repair or maintenance is required.

Requirement 2

- All concepts can meet the requirement to shear the B.C.A. and seal the pressure hull.

Requirement 3

- All concepts, employing direct drive hydraulic motors (low speed-high torque) can achieve the specified SOW Airborne and Structureborne noise per SKA 55250 and SKA55251. An optional direct drive concept - a solid state Torque Ring motor also appears capable of achieving similar performance levels.

Requirement 4

- The B.C.A. must be deployed and totally retrieved while the submarine is submerged at all operating depths.
- Interpretation of this requirement indicates that the B.C.A. end termination may have to be rethreaded through the Deploy/Retrieve Mechanism, rather than just inboard of the SUBSAFE boundary. If this is correct, operator accessibility would be desirable, but not essential.
- All concepts can be configured to meet the extreme condition of Deploy/Retrieve Mechanism rethreading.

Requirement 5

- All concepts, except for D, meet acceptable performance requirements for imposed, shear, tensile, compressive and torsional loading. Concept D requires a .5X bend radius.

Requirement 6

- All concepts have been configured to be installed within the confines of the existing structure.

Requirement 7

- The following breakdown in total envelope requirements is provided:

  Concept A - Refer to paragraph 1.6. -- 74.3 FT^3

  Concept B - Refer to paragraph 1.6 -- 82.6 FT^3

  Concept C - Refer to paragraph 1.6 -- 98.9 FT^3

  Concept D - Refer to paragraph 1.6 -- 73.7 FT^3 (limit condition)

  Concept E - Refer to paragraph 1.6 -- 90.2 FT^3

Requirement 8

- All concepts, except for E, provide accessibility - while submerged - for repair on the Deploy/Retrieve Mechanism and the Storage Assembly.

Requirement 9

- All concepts appear feasible of handling the minimum 1" OD x 1' long inline connectors and housings.

Requirement 10

- All concepts are compatible with the cable construction and materials of NUSC Specification NUSC-C-342/4141-279.

Requirement 11

- Capability of the respective system concept to handle a minimum 4" OD x 4' long antenna element is listed below:

  Concept A - Refer to paragraph 1.6 — 1" max.

  Concept B - Refer to paragraph 1.6 — 4" min.

  Concept C - Refer to paragraph 1.6 — 4" min.

  Concept D - Refer to paragraph 1.6 — 2" max.

  Concept E - Refer to paragraph 1.6 — 4" min.

Requirement 12

- All concepts appear capable of storing the required 3000 ft of BCA, including the goal of 5000 ft.

Requirement 13

- All concepts are capable of achieving the required $6000\#_f$ static tensile loading — and including up to a goal of $10{,}000\#_f$.

Requirement 14

- All concepts are compatible with .65 $\pm$.020 inch cable diameter.

Requirement 15

- All concepts can meet the minimum 200 FPM inhaul/outhaul speed requirement.

Requirement 16

- All concepts can meet the minimum $3000\#_f$ dynamic load requirement.

Requirement 17

- All concepts can meet the ± 5 foot cable scope measurement accuracy requirement.

Requirement 18

- Operation by two persons with a technical rating can be achieved by all of the DRSS system concepts.

Requirement 19

- The following breakdown in total weight, vs the required system weight of 3500 lbs., is provided:

  Concept A - Refer to paragraph 1.6 -- 3175#

  Concept B - Refer to paragraph 1.6 -- 4257#

  Concept C - Refer to paragraph 1.6 -- 10,539#

  Concept D - Refer to paragraph 1.6 -- 3175# (limit condition)

  Concept E - Refer to paragraph 1.6 -- 4635#

Requirement 20

- All concepts, except C, employ a hydraulic drive power train. Concept C is most amenable to an electric drive power train. This is due to the natural advantage of a free flood, non pressure compensated solid state torque ring brushless motor for this application.

Goal 1

- All concepts can meet the .50 → 1.00 diameter B.C.A. compatibility requirement. If the cable is continuously variable, only the dynamic seal configuration concept must be changed. Otherwise, the split, clamp, fixed, 2-position dynamic seal recommended for the DRSS would be applicable.

Goal 2

- All concepts can meet the 400 FPM inhaul/outhaul speed requirement. However, capability to achieve the Airborne/Structureborne Noise specification (Requirement 3) will be difficult.

Goal 3

- All concept configurations are capable of achieving at least $4125\#_f$ dynamic load by employing a Hagglunds 3160 hydraulic drive. The limiting factors relate to motor size (O.D.) which must be less than the hatch I.D. of the Main Access Trunk, and by the relationship,

$$\text{Theoretical Torque, ft-lbs} \approx \frac{\text{Displacement x } \Delta\text{PSID}}{24\pi}$$

where Dynamic Load Capacity is equal to:

$$\text{Dynamic Load Capacity}_{max} = \frac{\text{Theoretical Torque}}{\text{Single Drum Capstan Pitch Diameter}}$$

- Note that employment of a smaller pitch diameter for the Single Drum Capstan Configuration would provide a higher Dynamic Load. For example, Concept D, with an 18 inch Pitch Diameter requirement would achieve an 11,000 Dynamic Load Capacity.
- Note: a PMI solid state torque ring motor is capable of achieving $4700\#_f$ Dynamic Load. It would require approximately 400 Amps @ > 250 VDC. It has a 6 ft OD, with 24 to 36 segments and would have to be assembled inside the pressure hull.

Goal 4

- All concepts, except D appear capable of achieving a ± 1 ft scope accuracy.
- Assuming that the Single Drum Capstan pitch diameter is 48 inches, with a $\pm .0015$ inch machining tolerance;

  $48.003" \times \pi = 160.80116$ inches per revolution

  $$\& \ 48.000" \times \pi = \frac{150.79645}{.00471}$$ inches per revolution actual variance from ideal.

  $$\text{At Scope} = \frac{5000 \text{ ft} \times 12 \text{ inches/ft}}{150.79645 \text{ inches}};$$

  Revolutions required = 397.88735

  $\therefore$ Tolerance = .00471 in x 397.88735 rev/5000 ft

  = 1.874 inches/5000 ft.

- Similarly, for the B.C.A. diameter of .65 inches $\pm .020$ inches, yields a variance 6X greater than the .003 inches, or,

  6.67 x 1.874 inches = 12.54 inches/5000 ft.

Goal 5

- All concepts appear capable of being operated by 1 person with a technical rating -- presuming a fully automatic Deploy/Retrieve cycle.

Performance Achievement Factor

- Risk assessment of system concept configurations to achieve the SOW performance requirements, as characterized in the study effort is rated on a scale of 1 (high risk) to 3 (low risk).

  Concept A - (3)

  Concept B - (3)

  Concept C - (2)

  Concept D - (1)

  Concept E - (3)

- The above values represent an engineering judgement as to the intrinsic viability of each system concept, to be capable of achieving the SOW performance requirements. A rigorous risk assessment (for the recommended concept configuration) will be essential after a detailed definition is established in follow-on phases of the DRSS study effort. This would highlight critical areas that could be analyzed by experimental definition in order to establish conceptual feasibility.

Design Goal Achievement Factor

- Risk assessment of the system concept configurations to achieve the SOW goals, with 1 (high risk) to 3 (low risk).

GOALS

	1	2	3	4	5	$\overline{X} = \frac{\Sigma}{5}$
Concept A	3	3	1	2	3	2.4
Concept B	3	3	1	2	3	2.4
Concept C	3	3	1	2	3	2.4
Concept D	3	3	1	1	3	2.2
Concept E	3	3	1	2	3	2.4

- Refer to Performance Achievement Factor for rationale.

Development Risk

- Risk assessment associated with the development of each system concept configuration, with 5 (very high risk) to 1 (very low risk).

  Concept A - (2)

  Concept B - (3)

  Concept C - (4)

  Concept D - (5)

  Concept E - (3)

- Refer to Performance Achievement Factor for rationale.

Installation Impact with Respect to Wt., Vol. Limitations

- Risk assessment associated with capability of the various system concepts to be installed within the superstructure of the submarine without major ship alterations, 1 (high risk) to 3 (low risk).
- It is assumed that all major subassemblies shall be so configured (or assembleable) such that they can be taken into the pressure hull through the Main Access Trunk and assembled inside.

  Concept A - (3)

  Concept B - (2)

  Concept C - (1)

  Concept D - (1)

  Concept E - (2)

- Refer to Performance Achievement Factor for rationale.

Repairability

- Risk assessment of the system concept configuration's intrinsic viability to repaired while the submarine is underway, submerged, 1 (high risk) to 3 (low risk).

  Concept A - (3)

  Concept B - (2.5)

  Concept C - (1) very tight accessibility

Concept D - (1) very tight accessibility

Concept E - (-) inaccessible

- Refer to Performance Achievement Factor for rationale.

Unit Cost (Based upon maximum number of design goals)

Concept A - \$140K ±25% - similar to Concept B but w/o staging tube, 1 ea. FSSV and DCSA and reduced value sizes.

Concept B - \$172K ±20% - refer to paragraph 1.7 for a detailed analysis.

Concept C - \$300K ±25% - estimated at fabrication cost of the pressure vessel weighing approximately 7000# @\$25,000/lb. plus a base DRSS hardware cost of \$140 K+.

Concept D - \$172K ±25% - very similar to the Concept B requirements, but with a different storage assembly.

Concept E - \$215K ±25% - very similar to the Concept B requirements, but must add a divertor valve assembly and a B.C.A. transfer mechanism.

Interface Requirements Factor

- Based upon the subsystem tabulation of interactive components. The higher the value the more complex the system, and the less reliable.

Concept A - (12) — Refer to paragraph 1.6.

Concept B - (17) — Refer to paragraph 1.6.

Concept C - (11) — No operational dynamic seal.

Concept D - (17) — Similar to Concept B.

Concept E - (8) — No operational dynamic seals or valves. This would equal 18 for B.C.A. maintenance @ 1/10th speed and < 1/10th dynamic load.

Reliability Factor

- Based upon a tabulation of the subsystem failure rates per 1×10^6 Hrs, with $MTBF = 1/\lambda \times 10^6$ Hrs.

Concept A - 645 Hrs MTBF

$D/RM + SA + VLVS_{(3)} + SEALS_{(2)} + T/EP + C/GT + CP + Sensors$

$\sum\lambda = 250 + 100 + 300 + 628 + 100 + 50 + 50 + 75$

$= 1550$

Concept B - 472 Hrs MTBF

$\sum\lambda = 250 + 100 + 500 + 942 + 50 + 50 + 125$

$= 2117$

Concept C - 976 Hrs MTBF

$\sum\lambda = 250 + 200 + 300 + \text{-----} + 100 + 50 + 50 + 75$

$= 1025$

Concept D - 236 Hrs.

$\sum\lambda \leq 1/2 \sum\lambda$ Concept B, due to 3X RPM^{S} of the drive train

Concept E - 1600 Hrs

$\sum\lambda = 250 + 100 + \text{-----} + \text{-----} + 100 + 50 + 50 + 75$

$= 625$

APPENDIX B

APPENDIX B

DESIGN TO COST SUMMARY

A detailed Unit Production Cost (UPC) for System Concept B has been generated and is broken down as shown in Figure 1. In addition, an allocation has also been provided which relates Ship Alteration Labor and Installation Labor to the individual elements of the DRSS. Results of this analysis indicate that the UPC is equal to \$172,600 $\pm$20% vs the SOW goal of \$175,000, and that the Installation cost is equal to \$198,300 $\pm$20% vs the SOW goal of \$200,000.

The production cost is found by multiplying by two a base hardware cost estimate developed in either the respective tradeoff analyses of Volume II, or by extrapolation from existing manufacturer's hardware cost. In the cases where no direct comparison could be made, engineering judgment was employed to determine relative cost differences by utilizing subjective adjustment factors. The basis for these adjustments was established by comparison to the AN/BRA-18, AN/BRA-24, AN/SQR-19 winch, and the CHETSA system.

The installation cost estimate shown in Figure 1 was derived from the information in Table 1.

Final cost estimates for the other system concepts were based upon direct comparison to Concept B. This method provides a reasonable first cut at production and installation costs. When the system concept is refined, and the components are detailed, the accuracy of this estimation process can easily be improved.

ITEM:	PRODUCTION COST (1979 $)	SHIPYARD MAT'LS COST (1979 $)	SHIP ALT. LABOR — LEAD TRADES & SUPPORTING CRAFTS												INSTALL LABOR — LEAD TRADES & SUPPORTING CRAFTS											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1. TOW/EXIT POINT																										
a. SUPERSTRUCTURE MODIF.&FDN.	—	3,000*	1	2	4	2	2	2	6				1	2												
b. BELLMOUTH INSTALLATION	5,000	—													2										.25	
c. CONDUIT INTERFACE INSTALLATION	500	—													1										.25	
SUBTOTAL	5,500	3,000																								
2. CONDUIT/GUIDE TUBE																										
a. SUPERSTRUCTURE MODIF.&FDNS.	—	3,000*	2	1	4	4	4	2	12				2	2												
b. HULL INSERT (5IN)	—	3,000*	2	1	2	4	4		8	2			2	1												
c. STAGING TUBE ASSY INSTALL.																										
STAGING TUBE W/SEATATER VENT V/V	12,000	—													4										.2	
DYNAMIC SEAL ASSYS (2)	13,000	—													1										—	
FAILSAFE STATIC SEAL VALVES(2)	8,000	—													1										—	
MANUAL STATIC SEAL ASSYS(2)	4,000	—													1										—	
CABLE SHEAR ASSY.	4,000	—													1										—	
HULL VALVE (6")	10,000	—													2										—	
d. EXTERIOR CONDUIT INSTALL, 25' (O.S. PRESSURE HULL)	—	1,500							5						3										—	
e. INTERIOR CONDUIT INSTALL., 15' (I.S. PRESSURE HULL)	—	1,000							3						2										—	
f. ELECTRICAL INTERFACE(S)																										
BCA SENSORS	1,000	500										1	.25											1	.25	
STAGING TUBE ASSY INCL. VALVES, SEALS & SHEAR ASSY.	2,000	1,500										1	.25											1 2	.25 .25	
g. HYDRAULIC INTERFACE																										
VALVES,DYN. SEAL ASSYS & CABLE SHEAR ASSY.	3,000	1,500	2								6	1	1	1								4			.1	
h. DEPLOY/RETRIEVE MECH. INTERFACE	2,500	—													2										.25	
SUBTOTAL	49,500	12,000																								
3. STORAGE ASSEMBLY																										
a. STRUCTURAL MODIF. & FDNS	—	3,000*	2	1		4	4	.5	4				1	1												
b. STORAGE ASSY. INSTALLATION	19,500	—													8										.25	
c. ELECTRICAL INTERFACE	500	500									4	2	.25											2	.25	
d. HYDRAULIC INTERFACE	2,500	1,500								4			.25	1								4			.25	
e. R.F. INTERFACE (INCL. SLIPRING)	3,000	1,500										2												2	.25	
f. LEVELWIND INSTALLATION	7,000	—													3										.25	
SUBTOTAL	32,500	6,500																								
4. DEPLOY/RETRIEVE MECHANISM																										
a. STRUCTURAL MODIF.&FDNS.	—	3,000*	2	1		4	4	.5	4				1	1												
b. DEP/RET MECH. INSTALLATION	53,100	—													8											
c. ELECTRICAL INTERFACE	500	500									4	2	.25											2	.5	
d. HYDRAULIC INTERFACE	4,000	3,000								4			1	1								4			.25	
e. LEVELWIND INTERFACE	1,500	—													1										.25	
SUBTOTAL	59,100	6,500																								
5. CONTROL PANEL																										
a. STRUCTURAL MODIF.	—	1,500*	1			1	1						1	1												
b. SHIPS ELECT. INTERFACE	1,500	2,500										4	.25											4	.25	
c. CONTROL/INTERCONNECT WIRING	—	2,000										12	2											12	2	
d. CONTROL PANEL INSTALLATION	14,500											2	.5	1										4	1	
SUBTOTAL	16,000	6,000	12	6	10	19	19	5	40	10	14	27	14	12	40							12		30	10	
NET	$172,600	34,000	TOTAL= 186MD												TOTAL = 92MD											

Figure 1. DRSS System Concept B - Installation Cost

Table 1

DRSS System Concept B: Installation Considerations Summary

(<30 day conversion)

w/o Overtime

(1) All components must be assembled within the pressure hull -- capable of being taken through a 26 in. Dia. Main Access Hatch.

(2)a Ship Check by CID or equivalent -- <$2,500

b Support Services to Shipyard by CID < $5,000

(3) Foundations for: Conduit/Guide Tube

Storage Assy

Deploy/Retrieve Mech

Tow/Exit Point

Control Panel

Requires -- Ships Foundation Interface

Bedplate Installation

(4) Lead Trades & Supporting Crafts est. @ $20.00/hr. basis w/1 MD equal to 8 hours equivalent.

(5) Ships Interface for Hyd/Elect. Power, Water (if required), Control Wiring, etc., routing assumed within 100 ft of tie-in points.

(6) Elect. Conduit @ $6.25/ft x 400 = $2,500; Wire @ $2000

Guide Tube 5" @ $62.50/ft x 40' max = $2500

(7) Labor Summary: Lead Trades & Supporting Crafts

1	Outside Machinists	52 MD
2	Riggers/Crane Operator	6 MD
3	Carpenter (Staging/Safety)	10 MD
4	Welders	19 MD
5	Grinders	19 MD
6	Drillers	5 MD

7	Ship Fitters (Fitting/Welding, Str. Steel)	40 MD
8	Shipyard Test Organization	22 MD
9	Pipefitters	14 MD
10	Electricians	57 MD
11	Inspection	24 MD
12	Painters	12 MD/ 280 MD

(8) Comparison to CHETSA - @ < $50K for AFT #5 MBT installation shows ≈ < 32% Level-of-Effort.

(9) Assumed Shipyard O.H. + G&A + Profit @ 3.5X base of 280 MH yields $156,800

(10) Mat'l Cost (Shipyard) est. @ $34,000 + Support Services @ < $7500

(11) Total Est. Installation Cost equals $198,300 ±20%

(12) Total Production Cost equals $172,600 ±20%

(13) Future analysis should be capable of reducing the estimating uncertainty to a revised value ± < 10%.

(14) All other DRSS System Concepts will be compared by factor analysis -- relative degree-of-difficulty.